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Editorial

Water for food – Possibilities and Innovative Solutions

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Water, as in any other sector, is essential for agriculture and in turn for food security. The link is simple: crops and livestock need water to grow. To give a few examples, producing one kg of rice requires more than three tons of water and a kg of beef some 15 tons (Hoekstra and Chapagain, 2008). Dietary habits around the world, thus, have a significant impact on water consumption for food. A personal diet that is rich in meat can require over five tons of water per day. This is in stark contrast to the fact that around the world there are nearly 870 million people whose daily intake of calories is insufficient to live active and healthy lives (i.e. chronic undernourishment) (FAO, 2012).

With increasing population and changing consumption habits, food demand is predicted to increase by as much as 70% by 2050 (Bruinsma, 2009). There is enough water and land capacity to produce enough to feed humanity in the future only if we act now to improve water use in agriculture (CAWMA, 2007). An equally important aspect of food security question also revolves around the fundamental problem in the distribution of food and the resources with which to access it (FAO, N.D.). Consequently, the main challenge facing the agricultural sector is not so much growing more food, but making significantly more food available on the plate in the decades to come.

To achieve this target, it is necessary is to reduce losses in storage and along the value chain. However, the statistics are

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alarming: In least developed countries (LDCs) as much as half of crops produced are lost post-harvest while in OECD countries as much as 40% of food is wasted along the value chain and by consumers (WWAP, 2012). Reducing the food waste not only offsets the need for production of more crops but also help to reduce large water consumption.

While food security is a concern for all, what receives limited attention is that practically 70% of freshwater withdrawal at the global level is for irrigated agriculture. In LDCs this figure can be even more than 90% (FAO, 2011). Facing the competition from other sectors and due to more severe climatic variations and effects of climate change, water availability for agriculture is already limited and uncertain in several regions. This is set to worsen. Consequently, it is no longer enough to just think about the amount of water we need to grow food but we must also look at the way water is used from production to consumption.

Unsustainable water and land management practices to boost agricultural production have caused wide-scale changes in ecosystems and negatively affected the quality and quantity of water. The external cost of the damage to people and ecosystems and clean-up processes from the agricultural sector is significant. In the United States of America, for instance, the estimated cost is US$9–20 billion per year (Galloway et al., 2007).

Technology has an important role to play in improving productivity in agriculture while protecting nature. As 2012 edition of UN World Water Development Report (WWAP, 2012) puts it "*We will need innovative technologies that can improve crop yields and drought tolerance; produce smarter ways of using fertilizer and water; improve crop protection through new pesticides and non-chemical approaches; reduce post-harvest losses; and create more sustainable livestock and marine production*". This requires not only financial resources but good policy and governance. However, weak capacity and fragmentation of water-related institutions remain as key concerns in many regions.

Various scenarios suggest that if current population and consumption trends continue, by the 2030s, we will need the equivalent of two Earths to support us (GFN, 2014). While the validity of this claim is open to discussion, it does make the point that we cannot continue to consume natural resources at the current unsustainable rate if we care about everyone's benefit both now and in the future. Water will need to be managed so that supply and demand is balanced and shared in an integrated manner across sectors and across regions. This implies reducing the amount of water currently consumed to produce a reasonable and nutritious diet by improving on productivity and efficiency.

We are pleased to publish our Volume 2 Issue 1 of the "**Future of Food: Journal on Food, Agriculture and Society"**, on the theme of "**Water for Food**". The selected research papers presented in this Volume will provide further insight on problems and innovative solutions on Water-Food nexus in regional and global perspectives. Furthermore, this edition enriches with the video documentary titled, "More than Irrigation – The Balinese Subak system as a unique form of cooperative water resource management in Indonesia", book reviews that brings critical outlook of the thematic books and the report and analysis section with senior scientists' views.

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Connecting the Water and Carbon Cycles for the Generation of Food Security and Ecosystem Services

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Abstract

Water scarcity and food insecurity are pervasive issues in the developing world and are also intrinsically linked to one another. Through the connection of the water cycle and the carbon cycle this study illustrates that synergistic benefits can be realized by small scale farmers through the implementation of waste water irrigated agroforestry. The WaNuLCAS model is employed using La Huerta agroforestry site in Texcoco, South Central Mexico, as the basis for parameterization. The results of model simulations depicting scenarios of water scarcity and waste water irrigation clearly show that the addition of waste water greatly increases the agroforestry system's generation of crop yields, above - and below-ground biomass, soil organic matter and carbon storage potential. This increase in carbon sequestration by the system translates into better local food security, diversified household income through payments for ecosystem services and contributes to the mitigation of global climate change.

Keywords: *agroforestry; wastewater irrigation; carbon sequestration; water scarcity; food security; ecosystem services*

Introduction

Water scarcity remains one of the primary driving forces behind poverty, especially in the developing world. Largely a problem of distribution exacerbated by the poor's lack of social power and access to resources, water scarcity contributes to many symptoms of poverty, the most critical of which is food insecurity (Ahmad, 2003). Water scarcity is both a natural and human-induced phenomenon that is the result of physical or economic circumstances. Currently the effects of water scarcity are felt on every continent, with 1.2 billion people (one-fifth of the world's population) living in areas

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with physical water scarcity, while another 1.6 billion people (almost one quarter of the world's population) is affected by economic water scarcity (UNDP, 2006). The main cause of water scarcity is the uneven distribution of fresh water resources, compounded by inefficient water use, pollution of threatened water resources and unsustainable waste and resource management.

Poverty is more prevalent in the developing world and, in countries and regions with arid and semi-arid climates, water scarcity acts as the main limiting factor in biomass production, which contributes to lower crop yields, food insecurity and the poor's lack of access to other necessities of life, such as sanitation and building materials. Thus, if the issue of water scarcity is addressed, this is likely to hold positive implications on the status of food insecurity and poverty at the local and regional scales (Hanjra and Qureshi, 2010).

Under conditions of water scarcity fresh water resources are reserved for domestic use (i.e. drinking, cooking and cleaning) and sanitation, relegating the water needs of farm crops. In extreme cases only domestic uses are given priority, leaving crop production to the ravages of scarce and erratic precipitation. The main tenet of this paper is, therefore, that recycling treated waste water from domestic and sanitation uses for the irrigation of specifically designed peri-urban agroforestry systems could be a viable solution to the multi-faceted problems of water scarcity and food insecurity. The recycling of water for irrigation of agroforestry essentially connects the water cycle with the carbon cycle for the production of a variety of food products, carbon stocks in biomass and other environmental services.

A paradigm for the connection between the water and the carbon cycles is illustrated in this paper through the study of an irrigated, peri-urban agroforestry system at "La Huerta" in Texcoco, Mexico, a semi-arid area in South Central Mexico. The WaNuLCAS model (a model of **Wa**ter, **Nu**trient and **L**ight **C**apture in **A**groforestry **S**ystems, Van Noordwijk et al, 2011) is used to simulate the growth of crops and trees in an agroforestry system using the site conditions observed at La Huerta for model parameterization. The system consists of a mix of corn or maize (*Zea maiz*), a legume such as cowpea (*Vigna unguiculata*) and peach trees (*Prunus persica*) spatially organized in four linear zones. Simulation results are compared for scenarios of waste water irrigation and no irrigation (i.e. rain fed conditions which reflect water scarcity) at intervals over a time period of ten years. The performance of the systems in terms of carbon accrual (g/m^2) is compared based on a number of above- and below-ground carbon pools, namely: soil organic matter (SOM), tree biomass, harvested crop biomass, total carbon stocks and the resultant global warming effect of the entire system.

Methodology

Study Site Description

This study is based on field data collected from La Huerta agroforestry system at the Universidad Autonoma de Chapingo (UACh) in Texcoco, Mexico during July of 2012. UACh is located in the Valle de Mexico, east of

Mexico City. Dominant soil classes on site include haplic and luvic phaeozems of shallow to medium depth over volcanic bedrock (Cachón Ayora et al, 1974). This area has been under intense cultivation since pre-Hispanic periods when Aztec civilizations inhabited the area, thus contributing to the gradual depletion of soil nutrients over a long period of time. The landscape exhibits undulating foothills with sparse natural vegetation outside of extensively cultivated areas which constitutes the major land use in the area. The area receives unimodal rainfall with rains occurring from April to October totaling approximately 500-550mm per year, and a dry period running from December to March. The mean normal temperature is 18.5˚C ranging from 14 ˚C to 23.3 ˚C over the whole year. The mean normal temperature in the rainy season is 19.7 ˚C and 16.9 ˚C in the dry season.

La Huerta agroforestry system comprises 18 rows of peach (*Prunus persica*) and plum (*Prunus americana*) trees each separated with crop beds of maize, alfalfa, trefoil or maize mixed with beans. The total area of the agroforestry site is approximately 6,415 m^2. The site is primarily rain fed but is also irrigated using a ground water sprinkler system two times per month during the four month dry season. Following an unidentified pruning regime, prunings are removed from the site and composted with grass cuttings and livestock manure before being returned to the site. Compost is applied only to tree beds at a rate of ten kilograms per tree, per year. Trees on site are uniform in age and were approximately 12 to 15 years old at the time of the study. Photos of La Huerta agroforestry system are shown in Figure 1. For the purposes of this study, irrigation with waste water was simulated by using model parameterization options to mimic the nutrient concentrations reported in waste water in the area which receives little to no treatment. Waste water quality parameters were taken from the study by Vazquez et al (2007) which measured coliform and helminth contamination in waste water discharge to three rivers in the Valle de Mexico surrounding the city of Texcoco. Table 1 shows average values of contaminants, including heavy metals, found in waste water discharged to the three rivers measured at a number of discharge sites.

Modelling procedures

The WaNuLCAS model (Van Noordwijk et al, 2011) is used to simulate the growth of an agroforestry system using the site conditions observed at La Huerta in Texcoco, Mexico for model parameterization. The WaNuLCAS model uses the open STELLA modelling environment which ensures the model is modifiable by its user. The parameterized agroforestry system represents four soil layers with specified depths, and four spatial zones comprising trees and crops. Agroforestry systems in this model are defined on the basis of their spatial zones and a calendar of events for each zone including climate inputs, growing and harvesting trees and crops and fertilizer use. Interactions taking place within the agroforestry system that are most influential include shading by trees, competition for water and nutrients in topsoil between tree and crop roots, increased nitrogen availability to

Contaminant	Unit	Average value
Total N	mg L^{-1}	43.4
Total P		14.8
Pb		0.031
Zn		0.231
Ni		0.026
Cu		0.089
Cd		0.004
Helminth eggs	Number of eggs L^{-1}	2.03
Coliforms	Most probable number 100 mL^{-1}	2.46 x 10^8

Table 1 Waste water quality parameters measured by Vazquez et al (2007)

crop roots resulting from the death of tree roots following a pruning event or by direct transfer through contact with nodulated tree roots and long term effects on soil organic matter, erosion and soil compaction. Emphasis is placed on below-ground interactions where competition for water and nutrients is based on the effective root length densities of trees and crops and the current demand by both plant components (Van Noordwijk et al, 2011). A key feature of the model is the description of water and nutrient (N and P) uptake based on root length density, plant demand factors and the effective supply by diffusion at a given soil water content. The underlying principles which govern these processes are described in De Willigen and Van Noordwijk (1994) and Van Noordwijk and Van de Geijn (1996).

The effect of climate parameters is included via daily rainfall, average temperature and radiation data which are read from a linked spreadsheet. The effect of these conditions is reflected in potential growth rates of the plant components. The depth and physical properties of the four soil layers can be chosen within the model, which includes initial water and nitrogen content of the soil. The water balance of the system includes rainfall, canopy interception, exchange between spatial zones via subsurface lateral flows, evaporation, uptake and leaching. Both vertical and horizontal transport of water is considered. The N and P balance of the model includes inputs from fertilizer specified by amount and time of application, atmospheric N fixation, mineralization of soil organic matter and fresh residues and specific P mobilization processes. Leaching of mineral N and P is driven by the water balance and the N concentrations and adsorption constant in each layer. This allows for a ‘chemical safety net’ by subsoil nutrient adsorption. The actual growth of trees and crops is calculated on a daily basis by multiplying potential growth with the minimum of three stress factors; shading, water limitation and N/P limitation. A number of allometric equations are used to determine biomass accumulation in trees. Uptake of water and nutrients for both plant components is driven by demand on the basis of root length density and effective diffusion constants. The actual uptake of resources is given by Equation 1 and is calculated as the minimum of demand and potential uptake factors:

$$Uptake = \min(demand, potential uptake) \qquad \textbf{[1]}$$

$$PotUpt(k) = \min\left[\frac{Lrv(k) \times Demand(k) \times PotUpt\left(\sum lrv\right)}{\sum_{k=1}^{n}\left[Lrv(k) \times Demand(k)\right]}, PotUpt(Lrv(k))\right] \qquad \textbf{[2]}$$

Light capture is treated on the basis of the leaf area index (LAI) of all plant components and their relative heights in each zone. Potential growth rates for conditions where water and nutrient supply are non-limiting are used as inputs (potentially derived from other models) and actual growth is determined by the minimum of shade, water and nutrient stress (van Noordwijk et al, 2011).

Using the STELLA software and the linked Microsoft Excel files the WaNuLCAS model is parameterized to reflect the soil, climate and planting conditions observed at La Huerta agroforestry site. The cropping calendar shown in Figure 2 is part of the linked Excel table used for inputs to the model. Simulation run times were carried out for one, two, five and ten years in order to observe the system's development over time with respect to the observed variables, namely carbon and biomass accumulation. The system is divided into four zones, of which Zone 1 is populated with peach trees which remain through the entire simulation. Zones 2, 3 and 4 are planted with cowpea or maize on a two year rotational planting schedule. These crops were chosen for their similarity to the observed crops at La Huerta and based on existing data and parameters on their growth characteristics within WaNuLCAS tables.

In order to simulate waste water irrigation conditions at the agroforestry site reference values for water quality in the nearby Rio Texcoco were used for nutrient input values (Vazquez et al, 2007). Water from the Rio Texcoco is commonly used for irrigation of adjacent agricultural crops but is not transported to agroforestry systems in the region. The fertilizer and organic input schedule of the Crop Management model sector was used to simulate addition of nutrients to coincide with irrigation events, which were parameterized in the Weather sector of the model. Due to the untreated nature of waters from the Rio Texcoco which collects wastewater from nearby settlements and communities, nutrient concentrations and input volumes were applied at the highest values allowed within the external organic input parameters of the model. Figure 3 shows the graphic user interface (GUI) in the STELLA environment which is used to parameterize certain sections of the model and to execute and navigate the Run and Output sectors of the model. A view of the WaNuLCAS model layer in STELLA (Figure 4), showing only one section for tree water interactions, illustrates the modular complexity of the calculations involved in representing the myriad of natural processes considered within the model.

Results

The graphic results from WaNuLCAS model runs parameterized using La Huerta agroforestry site conditions are shown in Figures 5 through 8. Two scenarios are considered in the modelling: a) rain fed agroforestry where arid climate and water scarcity limits system development, and b) waste water irrigation conditions where water and nutrients are added to the system. Both scenarios are modelled for various time periods (i.e. one year, two years, five years and ten years) in an attempt to explore the long-term, cumulative effects of either water scarcity or waste water irrigation on agroforestry system development. Graphs generated in the WaNuLCAS output section show the accumulation of biomass (kg/m^2) by the crops and trees in each zone over time. For clarity's sake these results are synthesized in the graphs of Figures 9 and 10. Output tables in the WaNuLCAS interface show carbon accrual within individual above- and below-ground carbon pools including soil organic matter (SOM), tree biomass, harvested crops, as well as total carbon stocks accrued by the entire system and the system's global warming effect. A synthesis of carbon storage in these pools over the four timescales is shown in Table 2.

Discussion

This study seeks to compare the predicted performance of a peri-urban agroforestry system, in terms of biomass generation and carbon storage with a specific focus on food production, under conditions of water scarcity and waste water irrigation using the WaNuLCAS model. The aim is to demonstrate the advantages of connecting the water cycle with the carbon cycle, by re-using water that otherwise would be wasted, to sequester atmospheric carbon and to increase production of food crops. The issue of water scarcity is central to conditions of food insecurity and poverty, especially in the developing world (Rijsberman, 2005).

The results of simulations run in the WaNuLCAS model and based on La Huerta agroforestry system (Figures 5 through 8) show, over all

	1 year	2 years	5 years	10 years
	g/m² (grams per meter squared)			
SOM (lim)	3,100.0	3,044.1	3,267.6	3,217.3
SOM (ww)	3,573.3	3,923.5	5,070.1	6,233.3
Tree biomass (lim)	80.21	212.9	3,01.14	361.47
Tree biomass (ww)	114.52	389.26	1,639.5	4,578.98
Harvested crops (lim)	9.02	56.04	241.13	513.05
Harvested crops (ww)	84.04	340.51	1,365.46	2,685.31
Total C Stock (lim)	3,216.2	3,257.0	3,642.7	3,578.8
Total C Stocks (ww)	3,756.2	4,417.2	6,813.7	10,916.2

Table 2 Synthesized values of carbon storage in above- and below-ground biomass pools at intervals over a ten year period generated by the WaNuLCAS model representing La Huerta agroforestry system under water scarcity (lim) and waste water irrigation (ww) scenarios

timescales, a much greater, even erratic variability in biomass under conditions of water scarcity. It is also found that under waste water irrigation the production of biomass, SOM accrual and crop yields not only increase, but are also more sustained throughout the simulation period. The accrual of biomass and carbon in the waste water irrigated scenario increases significantly over time. As the agroforestry system matures these increases, relative to the rain fed scenario, become more significant. Total carbon stocks increase over time with waste water irrigation relative to the water limited scenario. This ensures that agroforestry farmers have a larger and more reliable harvest when treated waste water is recycled for irrigation purposes. By increasing crop yields this type of land-use management works towards improving food security at the household and community level, while simultaneously offering farmers the opportunity to sell surplus goods at market to supplement the household income. While the sale of farm goods is the most common method of farm income generation the production of ecosystem services, namely carbon sequestration, is a tangible way for farmers to diversify their income while improving the production performance of their farm (Wise and Cacho, 2007). The global warming potential of both systems (Figure 10), in terms of CO_2 equivalents per m^2, indicate that the mitigation capacity of the agroforestry system irrigated with waste water increases greatly over time, and is significantly greater than that of the water scarcity scenario. This is an added benefit to the enhanced food security that the waste water irrigated scenario represents.

The WaNuLCAS model was chosen for this analysis due to its consideration of many of the cooperative and competitive interactions which take place in agroforestry cropping systems. The parameterization of the system at La Huerta was made possible by the availability of different crop and tree species growth tables within supporting files to the model. Waste water irrigation is not a factor the model is designed to simulate, and so the parameterization of this scenario was executed in such a way that the model may not have been able to predict the associated effects with the same accuracy. Nevertheless, the results in this paper show clearly that enhanced food security and increased global warming mitigation can be synergistically achieved by connecting the water cycle to the carbon cycle using waste water irrigated agroforestry systems. These systems comprise a wide array of formats and functions that achieve goals of biodiversity conservation, food production and livelihood security (Droppelmann and Berliner, 2002, McNeely and Schroth, 2006).

While agricultural intensification and mechanisation can achieve increased crop yield in a monocropping system, indigenous agroforestry systems take advantage of the natural and successional variability of an area to generate a sustained and diverse array of products to achieve independent survival of the family and community unit (Alcorn, 1990). In this way, agroforestry as a small-scale farming practice can help to maximize resource use efficiency with respect to scarce natural resources (i.e. water, land, soil nutrients). This paper demonstrates that the water and carbon cycles can be effectively and efficiently connected to advantage, and that such systems can materialize, even under various conditions of water scarcity.

Conclusions

The results of this study and others referenced in this work yield a number of relevant conclusions.

1) Water scarcity is directly linked to conditions of poverty and food insecurity in arid regions of the world where unequal distribution of resources drives the cycle of poverty;

2) Under conditions of water scarcity crop irrigation is often forgone to assure adequate volumes of clean water are left for drinking, cooking and cleaning purposes. This results in low crop yields and food insecurity;

3) The application of agroforestry land use diversifies household income potential for small scale farmers;

4) Carbon storage, and thus biomass generation, in all pools is greater under waste water irrigation conditions. This is due to a greater availability of water during the driest season as well as nutrients (i.e. N and P) provided in the waste water;

5) At the end of the ten year simulation period harvested crop biomass (represented as carbon stocks) is five times greater under waste water irrigation than under the water limited scenario. This demonstrates positive relationship between waste water irrigation and food production, which leads to increased food security at the farm and community level;

6) At the end of the ten year simulation period carbon stocks accrued in tree biomass are more than ten times greater under waste water irrigation than under the water limited scenario. In this study where peach trees are planted in the agroforestry system additional benefits to food security and household income can be realized through fruit and timber harvesting;

7) Additional carbon storage in agroforestry farming systems provides farmers with the opportunity to receive payments for carbon sequestration on the voluntary carbon market. The global warming potential numbers under the waste water irrigated scenario show that, with a greater capacity to sequester carbon in biomass, the waste water irrigated system offers greater opportunity to farmers receiving payments for emission reductions. This benefits household income diversification, while synergistically having a positive impact on global climate change.

Overall, the agroforestry system irrigated with waste water performs better on all rankings than the system in the water limited scenario. This demonstrates that by diverting domestic waste water from the waste stream and recycling it to irrigate agroforestry farming systems, this conservative use of water can lead to increased carbon storage in tree and crop biomass. In this way we effectively connect the water cycle to the carbon cycle to achieve food security and climate change benefits at the local and global levels.

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Appendix

Figure 1 Planting arrangements at the agroforestry system at La Huerta site in Texcoco, Mexico

Crop planting schedule/cropping calendar

Select at most 5 types of crop you want to simulate (in capital)

here =>	E	B	C	I	J
Crop Number	1	2	3	4	5
	Cowpea	*Maize*	*Rice*	*Yours4*	*Weed*

Option for crop type

A	B	C	D	E	F	G	H	I	J
Cassava	Maize	Rice	Groundnut	Cowpea	Imperata	Sugarcane	Mucuna	Yours4	Weed

Back to READ ME

ZONE 1

No	Year of Planting	Day of Planting	Crop Number
1	100	304	2
2	100	80	2
3	100	304	2
4	100	80	2
5	100	317	2
6	100	359	1
7	100	71	1
8	100	361	1
9	100	354	1
10	100	359	1
11	100	354	1
12	100	317	2
13	100	317	2
14	100	317	2
15	100	317	2
16	100	317	2
17	100	317	2
18	100	317	2
19	100	317	2
20	100	317	2
21	100	317	2

ZONE 2

No	Year of Planting	Day of Planting	Crop Number
1	0	150	2
2	1	150	2
3	2	150	1
4	3	150	1
5	4	150	2
6	5	150	2
7	6	150	1
8	7	150	1
9	8	150	2
10	9	150	2
11	10	150	1
12	11	150	1
13	100	150	2
14	100	150	2
15	100	150	1
16	100	150	1
17	100	150	2
18	100	150	2
19	100	150	1
20	100	150	1
21	100	150	2

ZONE 3

No	Year of Planting	Day of Planting	Crop Number
1	0	150	1
2	1	150	1
3	2	150	2
4	3	150	2
5	4	150	1
6	5	150	1
7	6	150	2
8	7	150	2
9	8	150	1
10	9	150	1
11	10	150	2
12	11	150	2
13	100	150	1
14	100	150	1
15	100	150	2
16	100	150	2
17	100	150	1
18	100	150	1
19	100	150	2
20	100	150	2
21	100	150	1

ZONE 4

No	Year of Planting	Day of Planting	Crop Number
1	0	150	2
2	1	150	2
3	2	150	1
4	3	150	1
5	4	150	2
6	5	150	2
7	6	150	1
8	7	150	1
9	8	150	2
10	9	150	2
11	10	150	1
12	11	150	1
13	100	150	2
14	100	150	2
15	100	150	1
16	100	150	1
17	100	150	2
18	100	150	2
19	100	150	1
20	100	150	1
21	100	150	2

Figure 2 Crop and planting calendar for La Huerta agroforestry system as shown in Excel tables linked to the WaNuLCAS model.

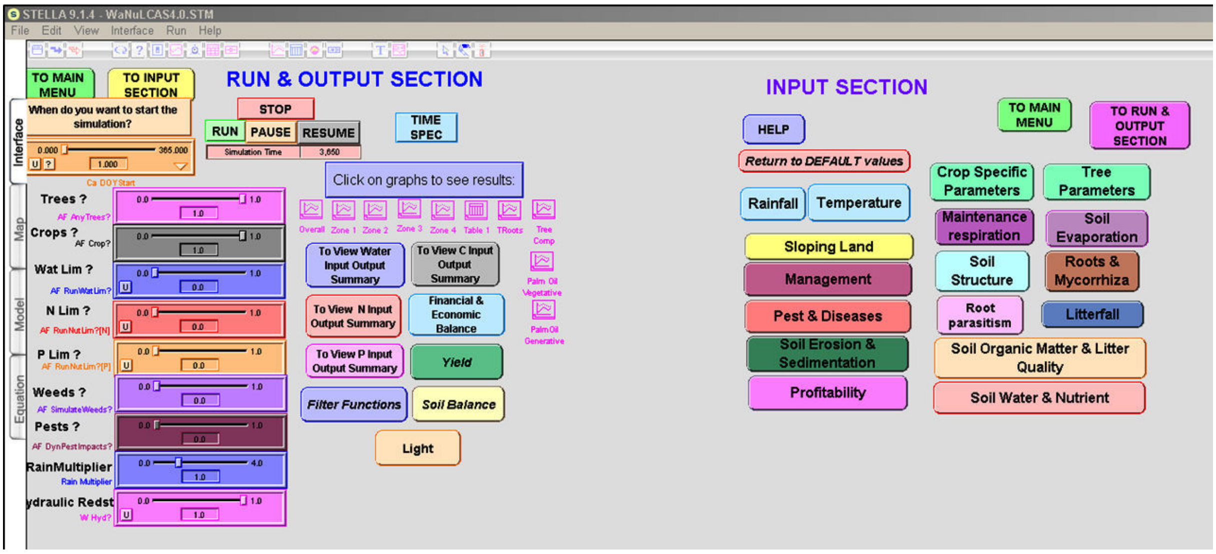

Figure 3 Graphic user interface of WaNuLCAS in the STELLA environment. This interface is used to operate certain model sectors including the Run and Output section where simulation results are viewed.

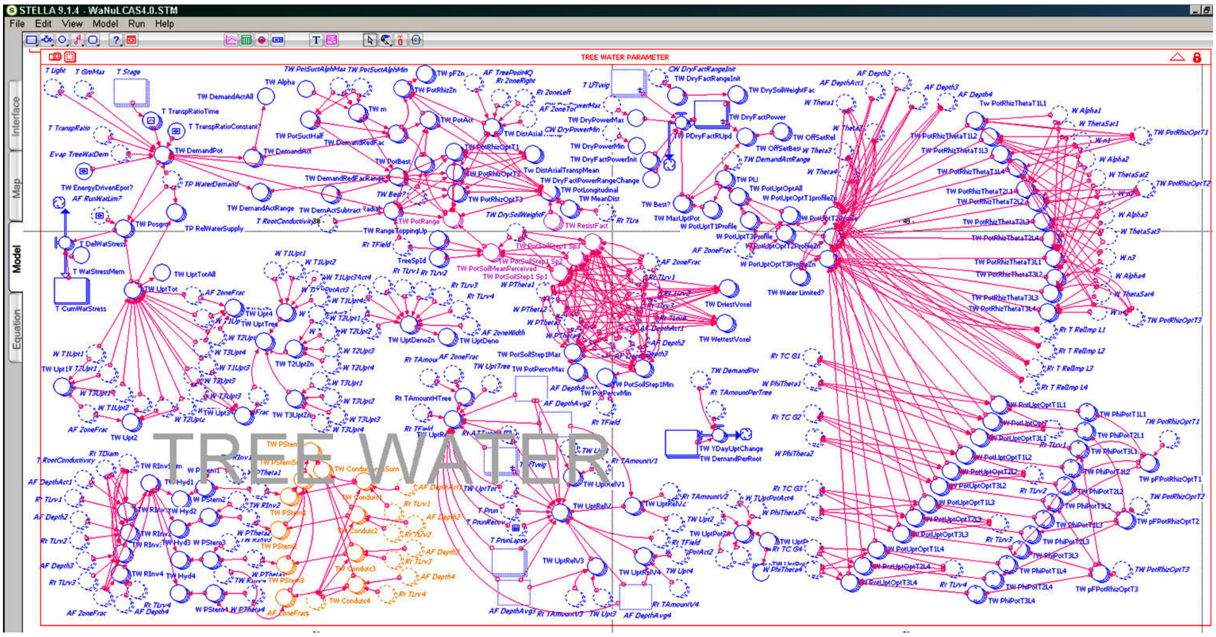

Figure 4 View of agroforestry system component interactions considered in tree-water calculations carried out within the WaNuLCAS model. Each pink line in this figure indicates the calculation of one relationship that represents a complex ecological process.

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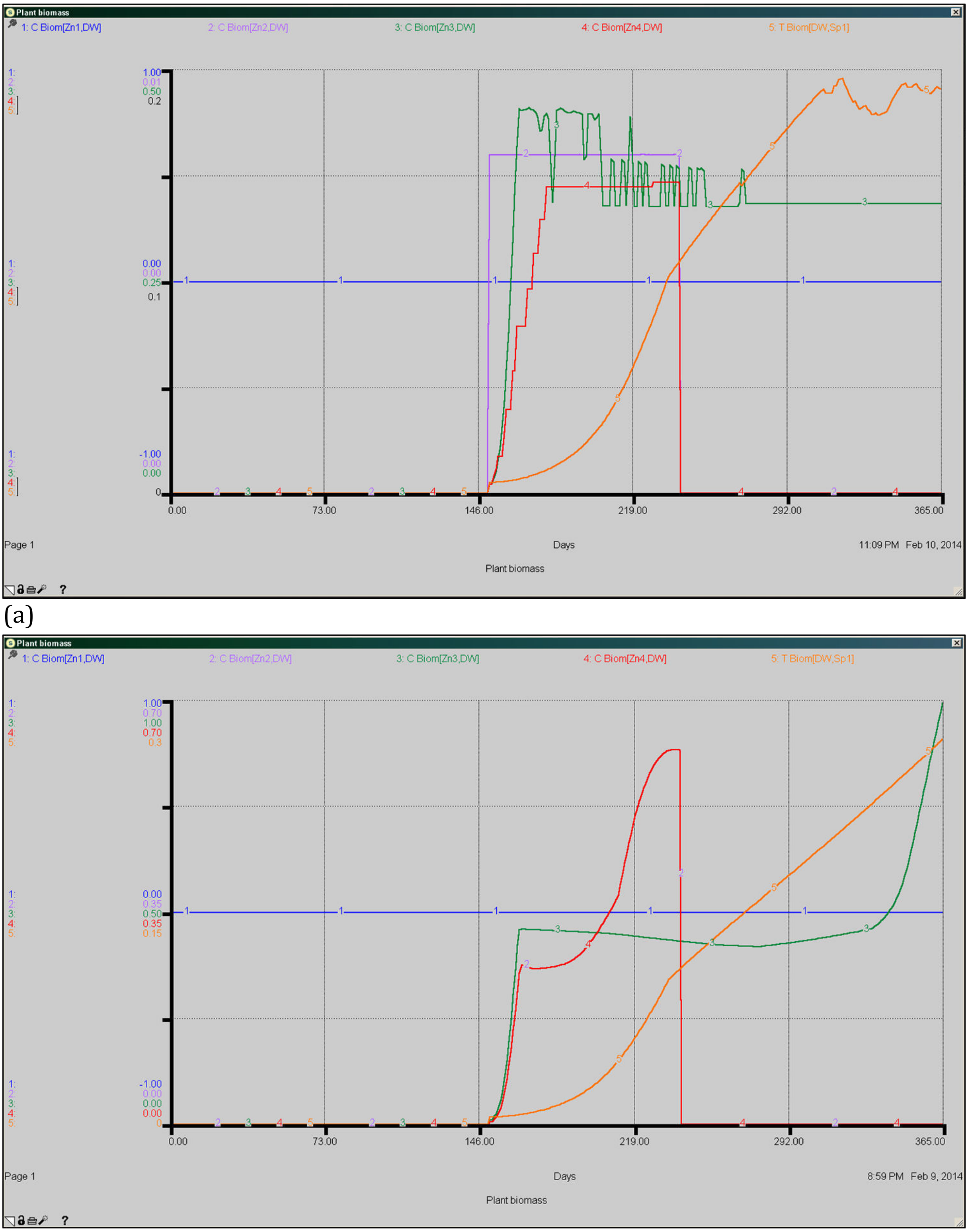
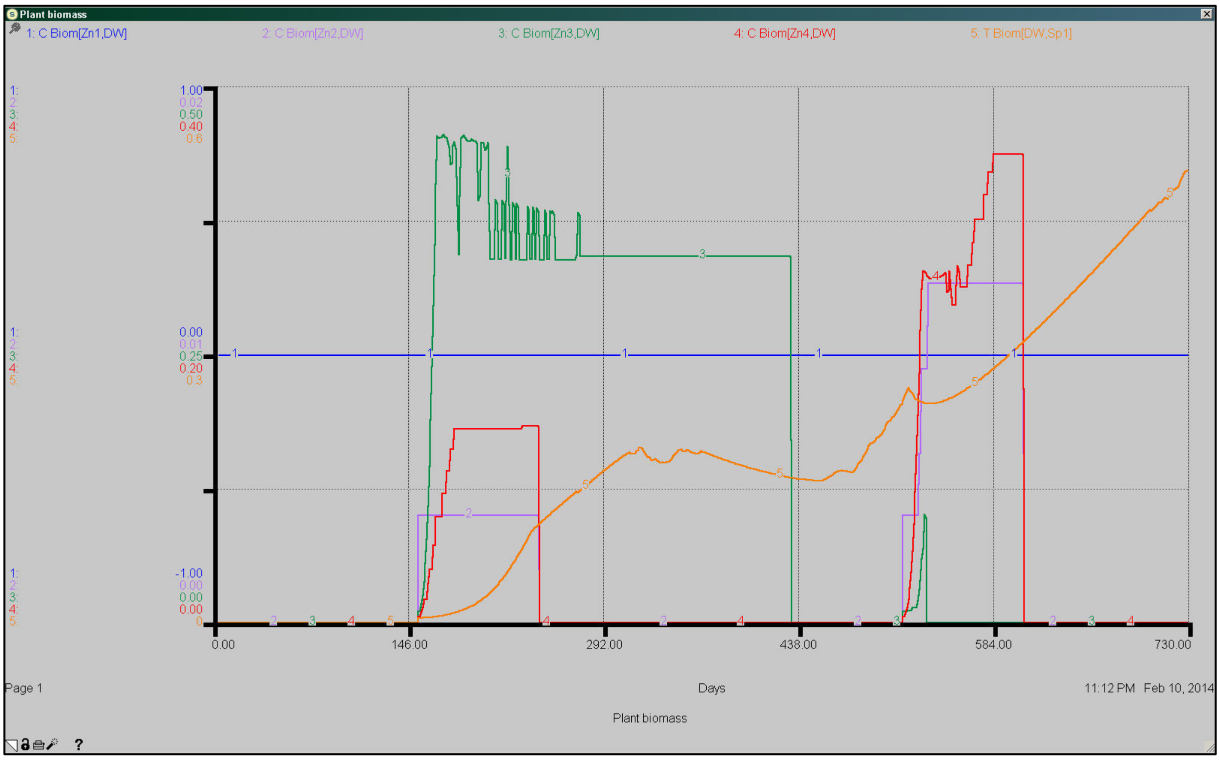


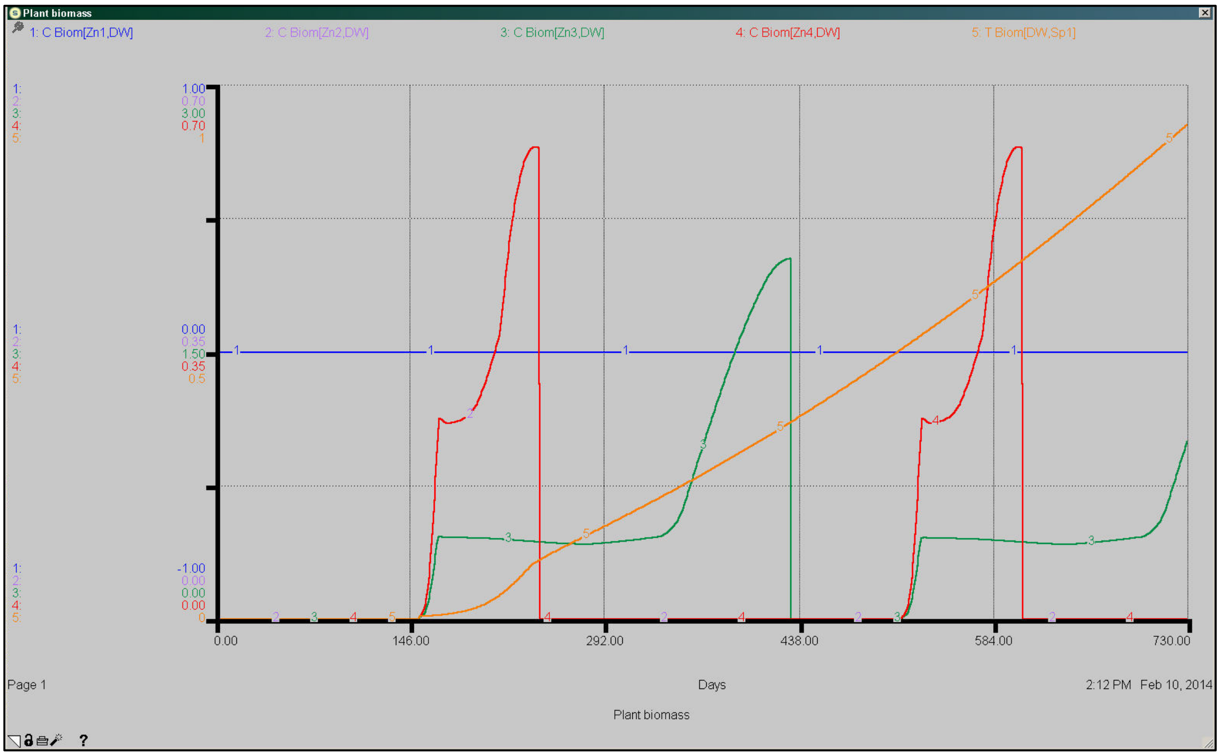
(a)

(b)

Figure 5 WaNuLCAS graphs showing biomass accumulation in kg/m² under (A) water limitation and (B) waste water irrigation. Simulation period: one year

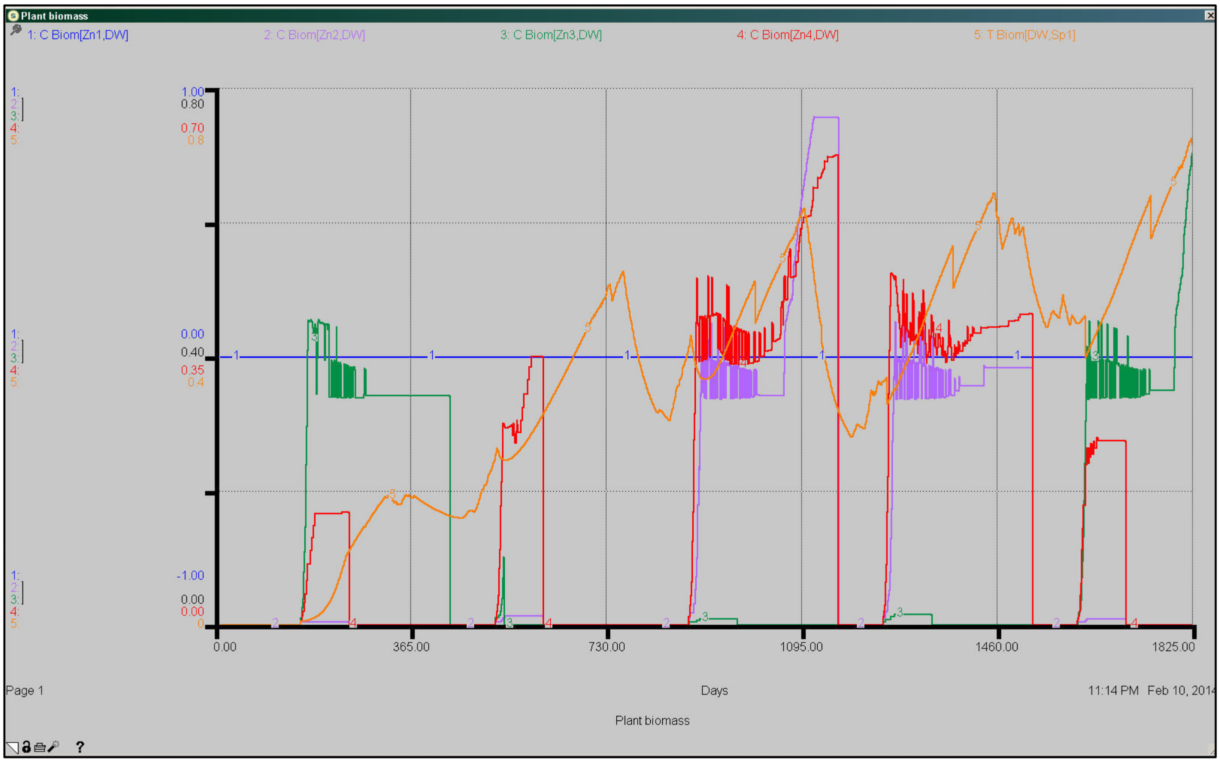


(a)

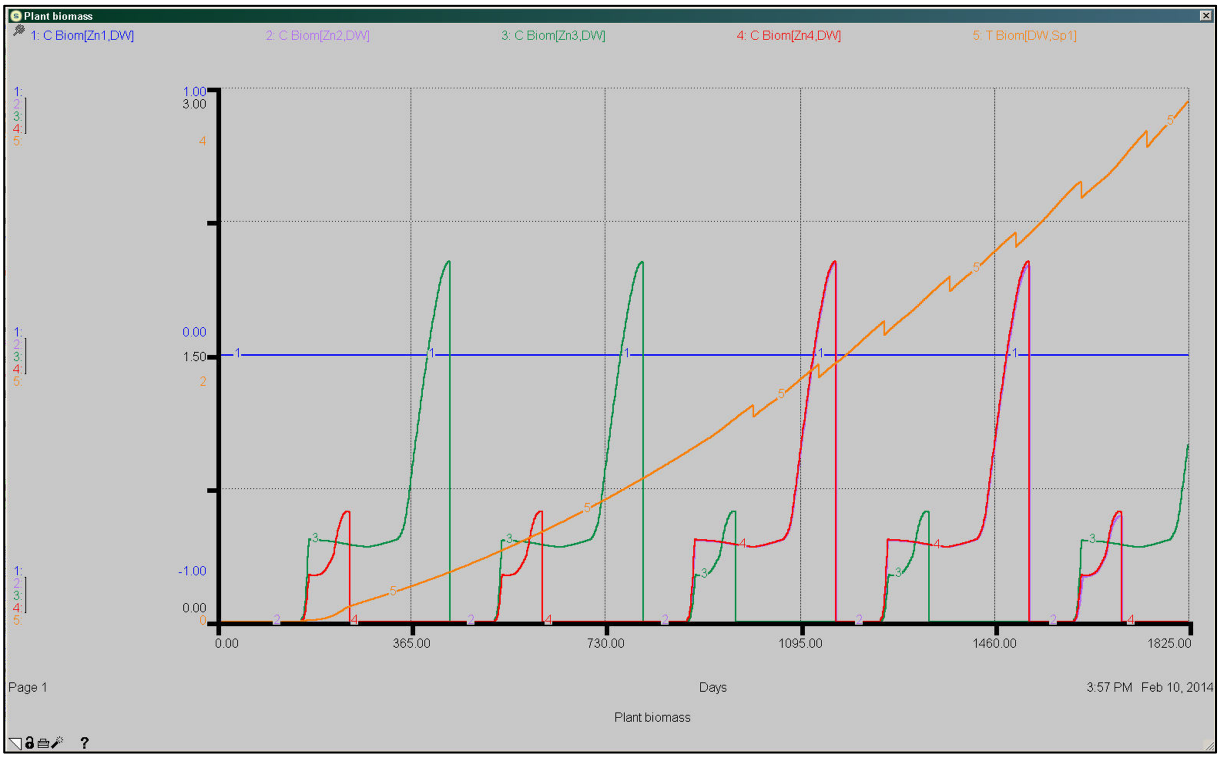


(b)

Figure 6 WaNuLCAS graphs showing biomass accumulation in kg/m² under (A) water limitation and (B) waste water irrigation. Simulation period: two years

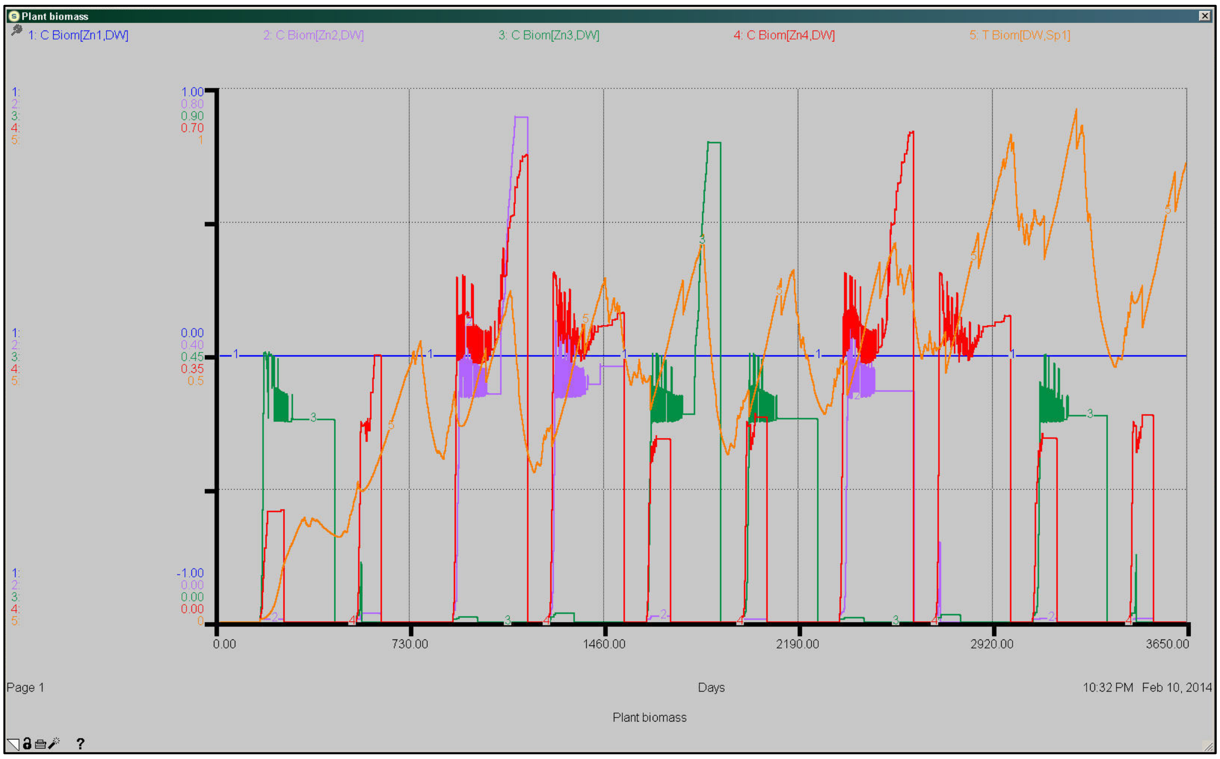


(a)

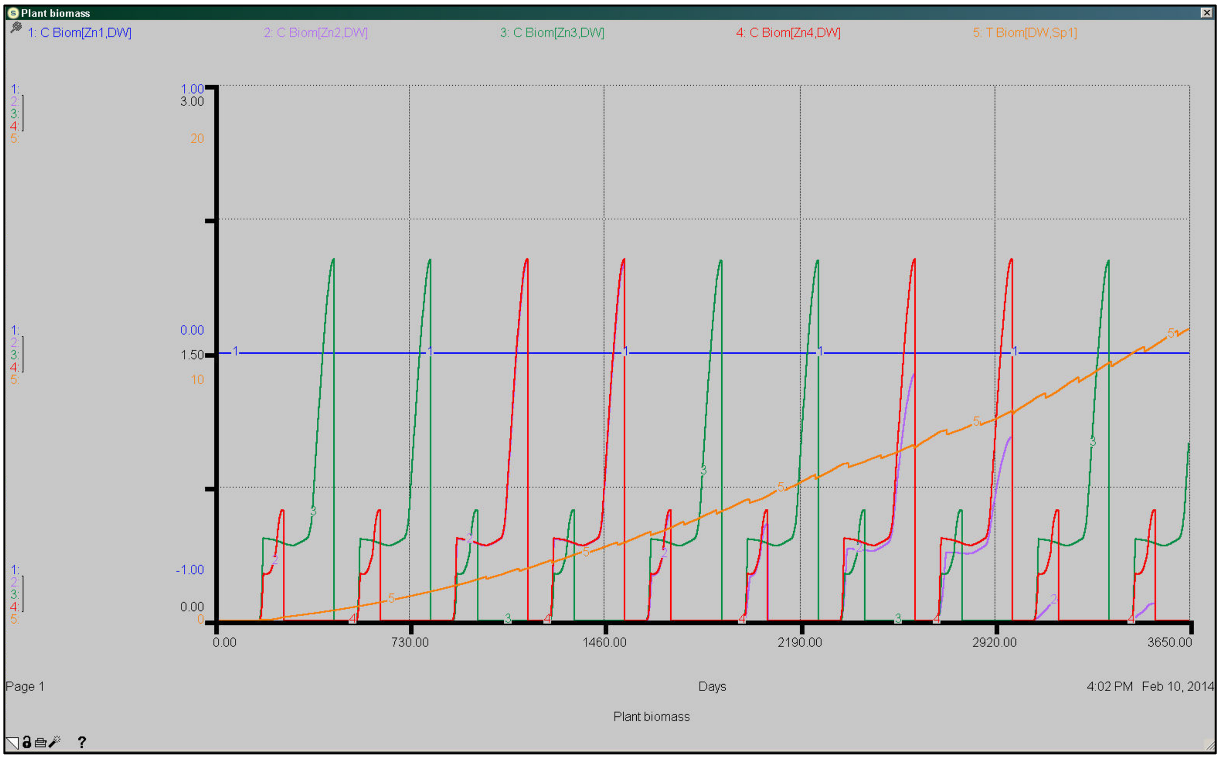


(b)

Figure 7 WaNuLCAS graphs showing biomass accumulation in kg/m² under (A) water limitation and (B) waste water irrigation. Simulation period: five years



(a)



(b)

Figure 8 WaNuLCAS graphs showing biomass accumulation in kg/m² under (A) water limitation and (B) waste water irrigation. Simulation period: ten years.

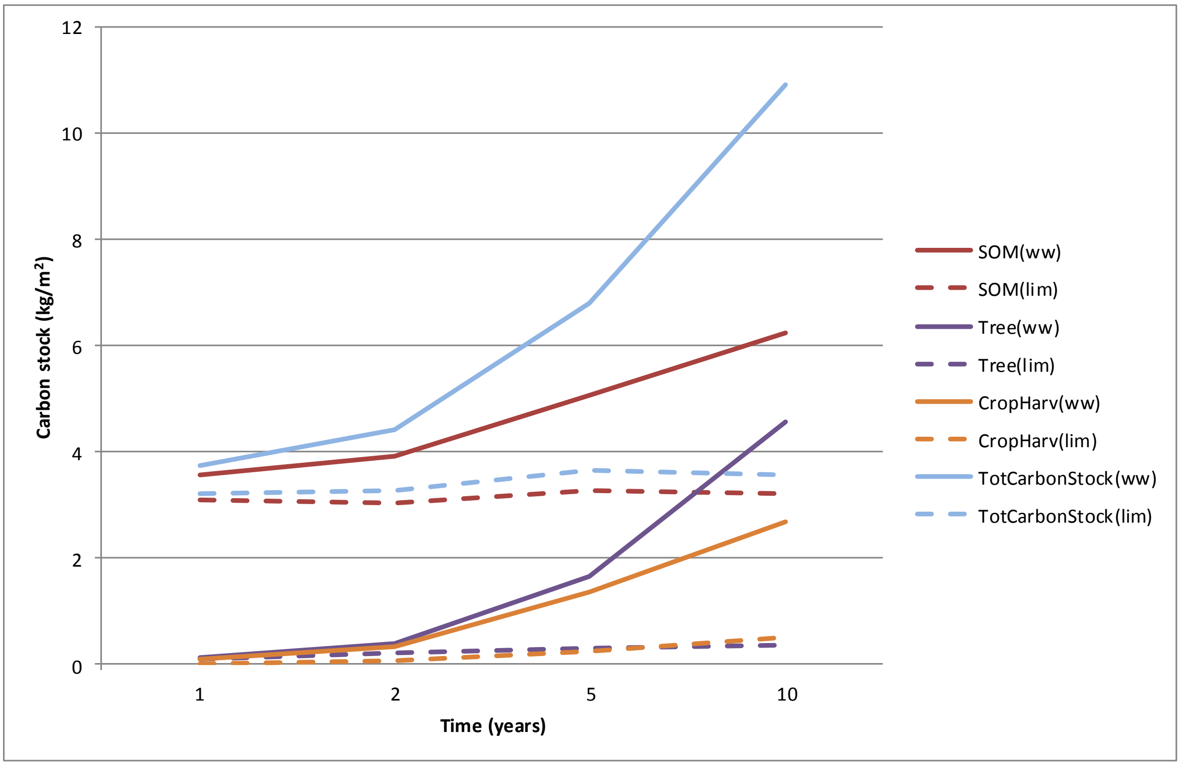


Figure 9 Carbon storage in above- and below-ground pools in La Huerta agroforestry system as predicted by the WaNuLCAS model for waste water irrigated agroforestry (ww) and the same agroforestry system under water scarcity conditions (lim).

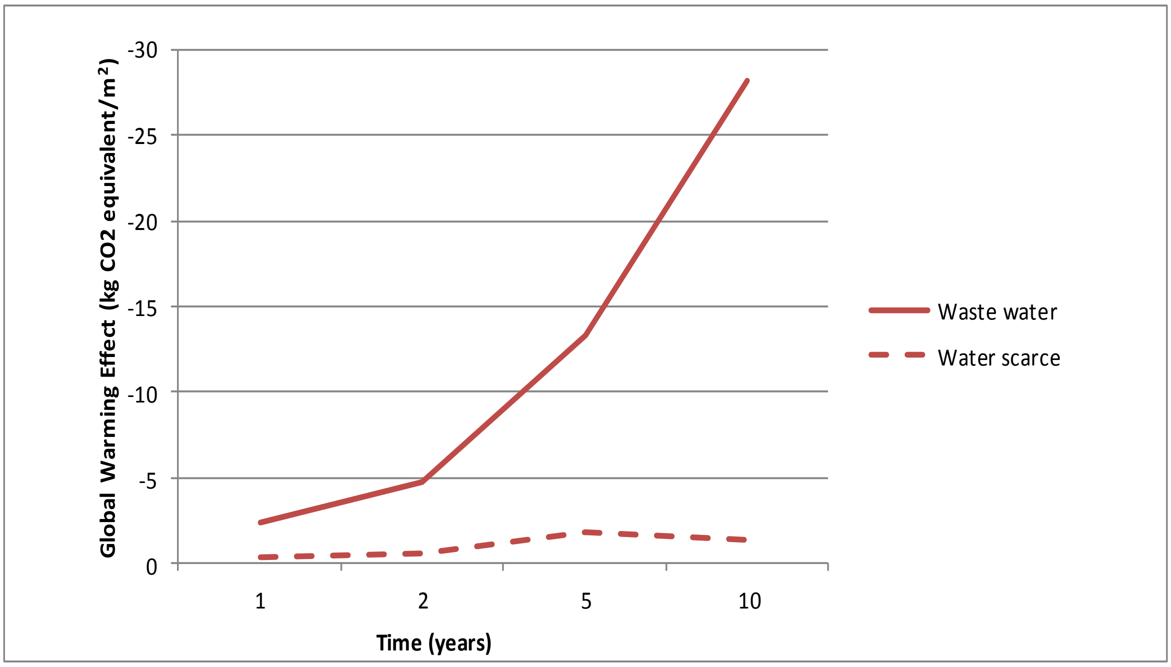


Figure 10 Total global warming potential of La Huerta agroforestry system as predicted by the WaNuLCAS model for waste water irrigated conditions (waste water) and water scarcity conditions (water scarce)

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Climate-adaptive Community Water Management for Food Security: Experiences from the UNDP Community Water Initiative

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Abstract

Facing the double menace of climate change and water crisis, poor communities are now encountering ever more severe challenges in ensuring agricultural productivity and food security. Hence, communities have to manage these challenges by adopting a comprehensive approach that not only enhances water resource management, but also adapts agricultural activities to climate variability. Implemented by the Global Environment Facility's Small Grants Programme, the Community Water Initiative (CWI) has adopted a distinctive approach to support demand-driven, innovative, low cost and community-based water resource management for food security. Experiences from CWI show that a comprehensive, locally adapted approach that integrates water resources management, poverty reduction, climate adaptation and community empowerment provides a good model for sustainable development in poor rural areas.

Keywords: *Climate adaptation; Water resource management; Community empowerment; Food security*

Introduction - Water Crisis, Climate Change and Food security

Water is a source of life for the planet. Access to water for life is a basic human need, a fact that is complicated by 1.6 billion people living in areas of physical water scarcity (UNEP, 2011). Yet in our increasingly prosperous world, 783 million people have no access to clean water and if the current trend continues there will be 2.4 billion people who lack adequate sanitation (WHO and UNICEF, 2014). Some regions are naturally water-scarce while others have over-used their available supplies, creating chronic water shortages. Even where water is available, it is often of poor quality and people may lack the technical and financial means to fully utilize their existing resources. The world's poor, who primarily live in the rural areas of Sub-Saharan Africa and South Asia, are particularly affected. They are the ones with the most

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inadequate access to safe water, yet they are also the population groups whose livelihoods and immediate dietary needs are most dependent on these resources.

Water is not only a basic human right in itself, but it is also critical in farming and other livelihood activities. Irrigated agriculture accounts for 69 percent of all water withdrawals in the world, and the proportion exceeds 90 percent in some situations such as in arid countries where irrigation is vital or where other sectors such as water supply and sanitation or industry are less developed (FAO, 2008). Water is the basic production element for agriculture: it takes 1,000-3,000 litres of water to produce one kilogram of rice and about 13,000 to 15,000 litres of water to produce one kilogram of grain-fed beef (IFAD, 2014). Hence, water resource management is critical to ensure sustainable agriculture development and food security. Globally, more than one billion people suffer from under-nutrition and the vast majority (98%) live in developing countries. Communities in South Asia and Sub-Saharan Africa, who also suffer most from water scarcity, face the biggest challenge of meeting their daily dietary needs. More than two thirds live in rural areas, where their livelihoods and well-being critically depend on subsistence farming and other ecosystem services in their area.

On top of the water crisis and its possible severe impact on farming and food production, climate change poses additional challenges for sustainable agriculture and food security. Climate change-induced variability in the hydrological cycle can not only deteriorate water sources and supply, but also increase unpredictability in water resource management. Rainfall and flood events are expected to intensify with more frequent and prolonged droughts in between. Changes in precipitation, increased evaporation rates, salt water intrusion into water systems along coastal areas, and reduced mountain glaciers and snow cover will all affect the availability of quality water supplies. For example, each degree of warming is projected to decrease renewable water resources by at least 20 percent for an additional 7% of the global population (IPCC, 2014). By mid-century, annual average river run off and water availability are projected to increase by 10-40% at high latitudes and in some wet tropical areas, while decreasing by 10-30% over some dry regions at mid-latitudes and in the dry tropics, some of which are already water-stressed (IPCC, 2007). These developments have critical effects on the rain-fed agriculture on which most poor communities in rural areas depend.

This paper draws on the experiences and lessons learned from the United Nations Development Programme (UNDP) Community Water Initiative (CWI) in addressing the complex interconnections between water, climate and agriculture. It presents a view from the grassroots level and discusses how the interlinking challenges of climate change, water crisis and food security issues can be addressed by rural communities. These issues are manifested differently under specific local conditions; hence this paper argues that community-based projects that

Country	Number of Projects	Number of Beneficiaries	Grant Amount	Co-Financing Cash	Co-Financing In-Kind	Total Budget
Mauritania	34	36,925	$585,1	$130,8	$255,4	$971,3
Mali	23	164,185	$500.0	$128,2	$108,6	$686,9
Niger	22	313,042	$465,7	$35,0	$117,4	$618,1
Senegal	21	71,443	$449,9	$96,2	$351,7	$897,87
Guatemala	14	17,268	$240,2	$349,8	$235,7	$825,7
Kenya	14	34,443	$207,5	$292,3	$57,4	$557,2
Sri Lanka	13	18,664	$220,5	$49,4	$100,1	$370,0
Tanzania	11	28,880	$171,6	$261,3	$107,3	$540,2
Uganda	8	13,865	$105,0	$29,7	$36,5	$171,2
Ghana	7	16,840	$94,9	$69,4	$70,0	$234,3
Total	**167**	**715,555**	**$2,990,2**	**$1,442,2**	**$1,440,0**	**$5,872,5**

Table 1 Summary Table of CWI Portfolio (Financial Numbers in‘000)

integrate water resource management, climate change, livelihoods and community empowerment can provide an effective development model for poor communities which are unreachable for larger development initiatives. The design of specific water management solutions for food security needs to take into account the specific context in which the community operates, including the multiple uses of water by men and women and other factors that shape access. Four cases of community-based water management for agriculture are presented and analysed for future learning and replication.

Community Water Initiative: Community Empowerment for Adaptation and Food Security

UNDP CWI is an initiative to address water and food issues at the community level. Launched in 2003, CWI has managed to build a strong portfolio comprising 167 projects in 10 countries. With a primary focus on Africa, projects were launched in Ghana, Kenya, Mali, Mauritania, Niger, Senegal, Tanzania, and Uganda. Pilot countries in South Asia (Sri Lanka) and Latin America (Guatemala) were added as well. More than 70% of the CWI projects and 74% of CWI grants go to the Least Developed Countries (LDCs). Table 1 includes the summary of the CWI portfolio.

CWI supports a decentralized, demand-driven, innovative, low-cost, and community-based approach to water resource management and sanitation projects in rural areas. It is rooted in the strong belief that local management and community initiatives play a key role in ensuring the direct relevance and sustain-ability of these initiatives. Relying on a holistic approach to water resource management, poverty reduction and community empower-ment, CWI has chartered a valid course towards sustainable food security for poor communities.

CWI has been implemented through the Global Environment Facility’s Small Grants Programme (SGP), which has since its launch in 1992 gained extensive experience focusing on supporting community-based actions to protect the global environment. CWI finds its synergies and linkages with SGP activities to ensure that the water supply and sanitation activities are green and environmentally sustainable. For example, through collaboration with SGP activities, CWI has introduced the use of solar energy in water pumping and integrated water supply activities with reforestation and organic farming.

A large share of CWI projects integrates the promotion of food security and sustainable agricultural practices as a core element in their project design. Increasing the availability of water has not only eased pressure on precious freshwater resources and land, but also provided water for farming and livestock activities. The provision of sanitation facilities, on the other hand, has facilitated the rehabilitation of terrestrial and aquatic ecosystems. CWI has thereby employed a range of innovative strategies to promote climate-adapted food security such as small-scale irrigation, dry-season gardening, soil-less agricultural techniques, and climate-adaptable crop varieties. For improved water supply, communities rely on a combination of traditional and innovative technologies such as rain and rock water harvesting, groundwater and watershed rehabilitation, and solar-powered pumps. All CWI communities integrating agricultural activities into the projects have been able to record substantial health improvements, particularly in child nutrition.

It should be noted that the community-based approach of CWI follows the principles of demand-drivenness in that communities themselves identify their needs and ensure community consensus in developing and implementing projects. Building upon the twenty years of community experiences from SGP, CWI has adopted an inclusive and participatory management approach that not only respects the traditions, values and cultures of local communities, but introduces elements of change to ensure transparent and democratic governance of the project (UNDP 2012). Part of this process includes a vulnerability reduction assessment at the beginning of each project, which pays particular attention to the social inclusion of vulnerable groups including women, youth, and the disabled. Particularly, CWI promotes gender mainstreaming by making women's participation a criterion for project proposal selection. Every project requires the community to form a gender-balanced committee to manage the new water scheme.

Methodology

In 2013, the authors conducted a global study of the CWI portfolio to review the progress made, identify good case studies, and collect good practices and lessons learned. The study team was composed of the Programme Manager and a consultant (the authors of this paper) who worked with the support of the CWI/SGP National Coordinators based in each of the ten participating countries. The study involved a global desk review and database analysis, survey, interviews and site visits. The ten SGP National Coordinators (based in UNDP country offices) played a critical role in obtaining and providing data and information from local communities, who actively participated in the global survey. Based on the findings from the global survey as well as recommendations from the National Coordinators, case studies were identified and developed to facilitate global learning.

The desk review involved the review and categorization of CWI projects based on specific themes and focus areas. 167 projects were reviewed, categorized and analysed by the types of activities and impacts achieved. The raw project information data are included on SGP online database (www.undp.org/sgp). Categorized projects were then sent to National Coordinators in the field to verify and validate.

Results and feedback from the projects were collected through a global survey which was completed by all 167 community organizations in the programme. Data and information were further analysed by the study team, and sent back to the field for verification and validation. Site visits were conducted by National Coordinators (some were through regular monitoring visits) to evaluate the project progress and to collect information on results. Interviews with project grantees, which were conducted as a joint effort between the study team and the National Coordinators, provided another source of information for the development of the case studies.

Cases of Community-based Water Management for Food Security

Revitalizing Ancient Irrigation Technologies near the Sigiriya World Heritage Site, Sri Lanka

Background

Located near the ancient city of Sigirya, Pollattawa village hosts the Pollattawa reservoir and an ancient canal called *Kapu Ela.* Over the course of time, the traditional lifestyle of the indigenous farming community in Pollattawa village had been lost, which led to the degradation of the local watershed area and made it difficult to meet the water needs for agricultural and domestic purposes. Pollattawa's 108 families used primarily groundwater for their daily water needs, which they accessed through three tube wells that were shared by two villages. Two of those tube wells served drinking water purposes while the third well was reserved for other domestic purposes. A few families were able to construct their own wells.

Farmers, who cultivated Big Onions as the primary crop, relied on water from the communal water storage tank or the *Kapu Ela canal* for irrigation purposes. However, harvests, which typically amounted to 3,000 kilos per acre, fell well below the projected amount of 5,000 kilos of onions per acre. In addition, the limited water resources forced farmers to spend more time on watering their crops, leaving little remaining time for other work on the farmland.

Project activities

With active engagement of the local community throughout the project, the CWI grantee Centre for Eco-Cultural Studies (CES) implemented a series of activities to help the community create a sustainable supply of water and rehabilitate the watershed area. The primary objective of the project was to revitalize the community's traditional rainwater harvesting techniques by renovating the ancient cascade system, including its tank ecosystems and ancient canal *Kapu Ela*. The canal harvests rainwater from the Yan-Oya catchment area and feeds into the Polattawa reservoir before it runs another seven kilometres to Pidurangala where the onion paddy fields are located.

The second objective was to rehabilitate the watershed area, by steering the community towards enhanced organic farming and non-timber products as source of alternative livelihood activities. Specifically, the project sought to upgrade the organic agricultural area with solar energy for improved access to irrigation water. The community selected ten farmers to pilot drip irrigation powered by solar energy water pumps. The water pumped from the well is supplied to the farmland through soil-based PVC pipelines, which run along the crop beds. Each pipeline has several tiny holes that drip water on the soil and, as the water is supplied near the roots of the plant, wastage from evaporation is minimal. Through this micro-drip irrigation system, the plants receive water all day long from morning to evening. This has freed farmers' time to increase weeding and fertilization activities to optimize effective agricultural practices in the area. Farmers have also been able to realize significant savings in fuel cost (around 60%) to run the water pumps, since the installation and operation cost of those solar pumps is minimal.

Organic farming production has been further strengthened through a few other steps. For one, the project sought to capture traditional knowledge on wild crops and local water governance through a series of documentation activities. This knowledge has then been integrated into farming activities, which have also promoted the cultivation and rotation of traditional crop species. In addition, the project has advanced organic fertilization to reduce water pollution by chemical fertilizers. On the ten selected farms, organic waste matter is now recycled into compost. A chopper is used to cut the large organic litter into little pieces, before cow dung and other materials are added to create the compost mixtures. The farmers can either use the compost on their farms or sell the compost on the market to generate additional income.

Promoting alternative, non-timber-product-based livelihoods also formed an important element of the project. Firstly, farmers opened a sales outlet for vegetables, fruits and other food items to cut the transportation cost for their produce to a market in Dambulla. Twenty families have also taken up beekeeping after they were trained in apiculture and honey production, and twenty women created micro-enterprises based on rush and reed products. Additional activities of the project included community awareness and education programmes, which sensitized the community to the issues of water conservation and management and built women's capacity to share these benefits and responsibilities on an equal basis. The community also established a water management committee to ensure equitable sharing and sustainability of the water scheme.

Results

The rehabilitation of the watershed area itself has promoted the recharging of the groundwater table. With the rehabilitation of the ancient cascade water supply scheme, increased availability and sustainability of the water resources have allowed the community to further develop traditional farming and domestic activities. The rehabilitation of the watershed area has promoted the recharging of the groundwater table. This has enabled the community to expand into alternative livelihood activities comprising the sale of organic produce, rush and reed products, honey products and compost. The project has also enhanced equitable water use and management among community members, especially for women. An important element of this process was the documentation of traditional knowledge, which informed the formulation of the new community-based water governance policies. These new policies are designed to ensure equitable sharing of benefits and responsibilities in the use of water resources and protection of traditional customary rights among all community members. The project serves as an exemplary model for revitalizing traditional practices and integrating them with modern, cutting-edge technologies.

Creating Safe and Sustainable Drinking Water Sources for People and Livestock in a Pastoral Community, Mauritania

Background

The project, which was initiated by the UNESCO Club for Culture and Environment, targeted a pastoral community in the Brakna region in southern Mauritania. Being located in the semi-arid Sahel region, it has one wet season between July and September, which is highly variable. Like many rural areas of Mauritania, the areas surrounding the village of Magta Lahjar have been facing limited access to safe drinking water. Wells constructed to supply water for local populations regularly dry up between March and July each year. During the wet season, people traditionally rely on surface water as drinking water for both people and their cattle. Since the water is usually shared among people and livestock and has generally been collected without any precautionary hygiene measures, the community frequently suffered from the effects of water-borne diseases. Over the course of the last three decades, severe droughts in the region have rendered access to adequate water resources increasingly difficult. These water issues have regularly forced the pastoral community to abandon their camps during dry season and seek refuge in the town of Magta Lahjar. Especially, the limited watering opportunities for their cattle posed a significant burden for the pastoralist community.

Climate change is resulting in additional uncertainty in precipitation. Average annual temperature has been increasing in the region (0.9°C since 1960), and is expected to continue this trend (McSweeney et al., 2009). Although forecasted precipitation trends are variable, amounts are expected to decrease with more rain falling in heavy events during the wet season and less during other times of the year. The combination of higher temperatures, lower but more intensified rainfall (with drier times in between), could result in more droughts and floods. With this increased climate variability, local communities will be more vulnerable to water shortage, threatening people's basic water needs and agricultural productivity.

The goal of the project was to develop the area's conservation and sustainable management of the surface waters to improve access to safe drinking water for both humans and animals.

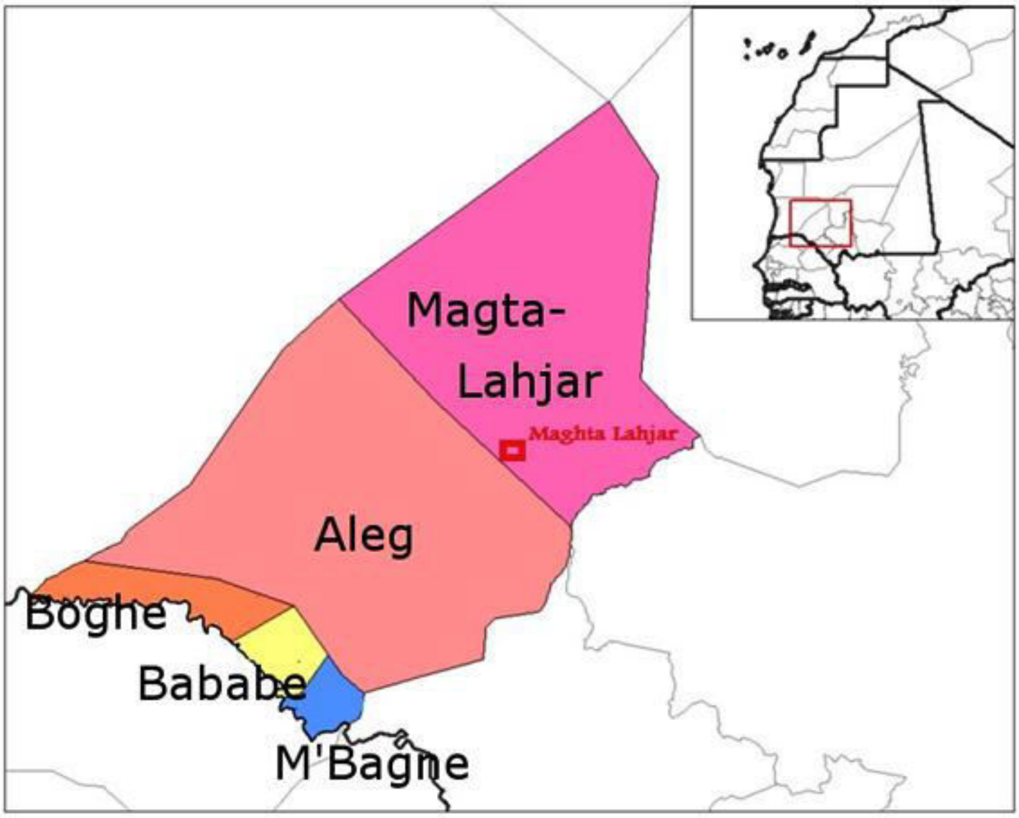

Figure 2 Project Site: Maghta Lahjar in Mauritania - Scale: 1:200; (Source: DATAR/MIDEC Année 2000, Mauritania)

To help resolve water scarcity and sanitation problems, several activities were undertaken as part of this CWI project. Firstly, the community constructed a series of diguettes (micro-dams) or rock lines along the contours of the gently sloping land. Rocklining promotes water and soil conservation by retaining surface water and promoting infiltration of rainwater to recharge the ground water. Rain and run-off water can develop a micro-climate for the cultivation of vegetation and crops between the diguettes, and thus promote the rehabilitation of the local environment.

In addition to rock lining, the project rehabilitated two wells and constructed two new wells for potable water. The project also set up small pools for water retention and built troughs to improve access to water for animals. Other important elements of the project constituted those of improving water management for agriculture and livestock watering. For this purpose, the community established a water management committee. To improve hygiene practices in the community, a series of sessions to raise public awareness on hygiene and sanitation were organized and water filters were distributed to households to reduce water-borne diseases.

Results

After completion of the project, the community has been able to permanently settle in their camps, being able to rely on stable access to drinking water for their families and their animals. The diguettes and improved water infrastructure have empowered farmers to rehabilitate their land and double agricultural production. In some cases, the project has also fostered agricultural diversification through the introduction of corn crops.

CWI's water infrastructure, combined with awareness and training sessions on hygiene practices achieved a significant reduction of water-borne diseases among the 1,200 beneficiaries in the project area. Improved water, nutrition and sanitation have had a particularly positive impact on children's health. As children missed less school due to illness or water collection duties, school attendance improved as well. In terms of capacity building, CWI has fostered leadership and institutional development for the construction and management of the water infrastructure, which is maintained by a community committee. These developments have also reduced conflicts between local water users.

Reconstruction and Rehabilitation of a Dam for Water and Food, Mali

Background

The village of Tinkélé is located 120 kilometres from the capital Bamako in south-western Mali. Though rainfall is sometimes abundant in southern Mali, the land tends to quickly dry up afterwards. Droughts are also commonly placing additional stress on the water resources. The resulting water shortages have made conditions difficult for life on traditional lands, often forcing local people to resort to income generation that has devastating consequences for the local environment, such as the production and sale of timber and charcoal. Deforestation and wood fires have not only resulted in severe degradation of local lands and loss of biodiversity, but also contribute to climate change in the long term. Overall, annual 5 day rainfall maxima have decreased by 4.0mm pe r decade since 1960 while temperatures have increased by 0.7C. Climate change projections are difficult to undertake for the Sahel which faces high hydrological variability. Various projection models estimate, however, that the south-western corner of Mali, the location of

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the project site Tinkélé, will experience the largest decreases in total rainfall in Mali during the wet season (McSweeney et al., 2009).

Project activities

Given the widespread shortage of water and land degradation, local villagers sought the assistance of the NGO Survie au Sahel in building a dam to store water for stable access to water, promoting land rehabilitation, and fostering economic development. After project completion, however, the community soon realized that the small dam was not sufficient in securing sustainable water supply and water was being lost through leakage.

CWI provided funds to enhance the design of the dam and create a filter system to better manage seepage flows. By expanding the initial dam, its storage capacity has been tripled, providing many benefits to the local population. Specifically, the improved water scheme offers year-round access to water for people and livestock, while helping recharge the groundwater and raising water tables for local wells that supply water for domestic and agricultural purposes. A village water committee was established, which has taken on the responsibility of overseeing and managing the dam and related water resources.

Results

Improved availability of water has increased agricultural production and enhanced counter-seasonal gardening, which provides an important source of livelihood for women. In addition, the project reintroduced indigenous trees and plants, like the Jujube, that yield fruits and can be sold at local markets. The increased availability of water and plants also attracted bees to the area, enabling apiculture and new business opportunities for the production and sale of honey products. The local women managed to improve production and pricing for their products by organizing themselves into a cooperative.

The combination of increased agricultural and economic development and a heightened awareness about environmental issues has decreased timber harvesting and charcoal production as a source of income. Conversely, the presence of water has spurred an increase in herbaceous and woody plants in the area, which, besides capturing greenhouse gases, also creates a micro-climate favourable for rehabilitation and conservation activities.

Safe Drinking Water for the Community in Belen, Guatemala

Background

Nestled in the high lands of Guatemala in the Tacaná region of San Marcos, the rural community of Belen faced difficult living. Extreme poverty conditions in the community was perpetuated by poor housing and inadequate access to safe water. Women were responsible for supplying water, which they usually collected from a polluted river in the upland. The water supply for drinking and cooking was collected from the same areas where women washed the laundry. The community relied almost exclusively on rain-fed subsistence farming which was, more often than not, insufficient to feed their families. The local forest and watershed also suffered from severe degradation through wood cutting to clear land for agriculture and to collect fuel wood for cooking. The effects of the tropical storm Stan, which had caused extensive damage, further exacerbated forest degradation. Realizing that 60% of the forest had been lost and water supply conditions had further deteriorated, the community decided that rehabilitation measures needed to be urgently taken.

Project activities

The women-led CBO Comite de Desarrollo Integral Comunitario initiated a CWI funded project to implement a gravity-fed drinking water system for the community, which also included one elementary school. By tapping water from four local springs, the gravity-fed water scheme stores the water in two new storage tanks before distributing the water to individual household tabs through a piped network. To finance the water scheme, the community decided to raise the money collectively. In each household, one male member left for Mexico to earn and contribute money towards the new water infrastructure (widow households were exempted). The collective effort, which built on the community's traditional, ancestral village organization, ensured that the entire community would benefit from having water in their homes. The community members, of whom a quarter is indigenous Mam, also received training in the installation and management of the water distribution system. With the goal of improving water efficiency, the community of Belen set water usage rules and formed a committee for the management and maintenance of the water system.

A core element of the project involved reforestation activities to improve water catchment and replenishment of aquifers. Recognizing that future conservation of resources is mainly in the hands of their children, the community made a special effort to include children from elementary school in the reforestation activities. Striving to conserve indigenous varieties, the community created a tree nursery with local seeds from alder, pines and cypress, which they had collected from the local forest. As a result, one hectare of forest has been rehabilitated around the field springs each year for conservation and sustainable wood harvesting purposes. Since 2007 with the rehabilitation of the forest, springs have been replenished and serve as a stable source of water.

Various soil preservation techniques for slopes and mountainous terrain were also introduced to diminish soil erosion, mud slides and landslides during the rainy season. Home gardens were equipped with soil preservation structures like terraces, contour lines and rainwater harvesting pits. In addition, some home gardens implemented agroforestry measures to create windbreaks. With these improvements, the community has been able to expand farming into the dry season, thereby increasing production of local produce varieties which included potatoes, corns, beans, lima beans, carrots, broccoli, cabbage, apples and peaches.

As many children in the community suffered from water-borne diseases, the project also sought to strengthen the community's capacity in managing health. With the participation of teachers from elementary school and the women of the community, several trainings were implemented to educate about clean water, food handling and personal hygiene.

Results

The woman-led project implemented a gravity-fed water system that supplied drinking water to all households in the community. In addition, the soil preservation and reforestation activities helped revitalize the watershed area including groundwater, springs and the forest. This has enabled the community to expand agricultural production and consistently meet dietary needs for their families. Furthermore, farmers have been earning additional income from selling produce surplus on the local market. A combination of reforestation and soil preservation techniques have thus not only improved water supply for farming but also reduced the community's vulnerability to climate change related hazards such as tropical storms. The trainings in personal and food hygiene reduced water-borne diseases by 70%. Together, clean water, improved food and hygienic practices improved the health among community members.

Discussion

Successful community-based projects are multi-faceted, and offer a package of comprehensive solutions to all development needs, such as water, food, climate adaptation, education and gender. Water management without considering the needs of communities, their livestock and farming could lead to the further depletion of water resources. Water management should go hand in hand with analysis of agricultural activities and promotion of water-efficient agricultural activities. Similarly, social-economic conditions should be included in development and implementation of projects. For example, in many water deprived rural areas, the burden of water-fetching and harvesting falls on women and girls who also play a critical role in providing food for their families. Given these high stakes, women have a strong commitment to make food and water-related project activities successful. Gender empowerment is therefore a critical component in the design and sustainability of such projects.

It is important to recognize the role of economic benefits in any development programmes for poor communities. In the context of poor rural areas, such economic benefits are highly related to enhancing agricultural productivity for food security. With improved water supply and sustainable, climate-adaptive agricultural techniques, local people can achieve more secure food production. Effective on-the-ground projects have combined a wide variety of activities that integrate water management measures such as irrigation, rainwater harvesting, spring water protection, dam construction and others with agricultural activities such as crop farming, fruit tree planting, and drought-resistant vegetable cultivation.

All cases show the great need to develop local capacities and community-based management arrangements to run community-based activities. CWI projects mobilize local leadership and community participation by developing local, gender-balanced water management institutions. Such management committees or groups have been established and continue managing water resources beyond the completion of the projects. Local people have been trained in the maintenance and repairing of water facilities, and the management of water resources. Such an approach recognizes that building the management capacity of the communities ensures the sustainability of impacts and benefits achieved.

Conclusions

Water management and food security are highly complex and context-specific issues that require micro-level analysis and interventions. Water resources, their uses and threats are specific to local conditions, as climate change impacts are manifested differently across local levels, and choices in livestock and crops cultivation are highly related to local environmental and physical conditions. Hence, development efforts should involve detailed analysis of local conditions and local development needs, and activities should be initiated and owned by local stakeholders.

It is important to recognize and promote communities' roles in addressing their specific water, food and climate challenges. While the international development community seems to have reached a consensus on the role of climate variability in complicating the water-food nexus, there has not been an adequate amount of investment and attention to the needs of local communities in dealing with these issues. This paper calls for more action at the local community level and advocates for governments to incorporate community-level experiences and lessons learned into government programmes and policies.

Acknowledgement

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Wastewater Treatment Project for Palma Soriano, Cuba: Assessment of Cultural and Ecological Conditions

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Abstract

The Palma Soriano's Wastewater Treatment Project is a proposal to use cultural identity as a trigger to reverse ecological degradation. The research methodology draws from environmental, social and urban analyses to unveil the best strategy to address the ecological, river restoration, agricultural, and water treatment challenges in Palma Soriano, southeast Cuba. The primary objectives are to provide a better quality of life and to create new opportunities for the local community to reconnect with natural cycles of water and the cultivation of their own land. The research shows that stopping the processes of desertification combined with forest restoration of the upper of the Cauto River, where Palma Soriano is located, is critical to the achievement of these objectives. The project promotes the strength and capacity of local people to protect their own environment by proposing a community-based master plan for public spaces, cultivation areas, new sanitary and storm water treatment infrastructure, and restored natural landscapes on the Cauto River. The project includes natural wastewater treatment, reforestation, community urban agriculture and a public commons along the river. This project will produce healthy water recycling, provide a potable water source for the city, encourage ecological restoration of the riparian zone, and provide new opportunities for food production. It is derived from and designed to preserve the cultural identity of the local community, and to restore the essential balance between the community's need to sustain itself and the natural environment.

Keywords: *Water Treatment; River Restoration; Community Identity; Local Food Production;*

Introduction

The impetus for this water treatment project is the interest in local communities with strong spiritual ties to their environment – where a close relationship between culture and environment is cultivated and nourished (Heidegger, 1951; Norberg-Schulz, 1980). This article explores some of the dilemmas that arise when the human need for water quality and food overpowers the ability of the natural ecosystem to support the demands.

The research is presented in the context of ecological design – an emerging framework for re-envisioning the built environment in terms that encourage the dynamic, positive, and mutually beneficial interaction between humans and the ecological world (Mozingo, 1997). This paper is a proposal for an ecologically based water treatment project for Palma Soriano in Southeast Cuba: It is also a proposal for re-imagining the complex web of

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interactions among people, the built human environment, community identity, urban agriculture, and the supporting natural ecosystem. In order to achieve such a solution, this paper first identifies a potential community and environmental problem. Second, it develops an analysis of the area and recognizes the main problem. Third, it presents an integral solution of the problem. And finally it discusses this specific project in relation with a global context, and evaluates the solution proposed as a solution for other areas that have been affected by similar social and environmental injustices.

The research project also uses a socio-metabolic perspective on the "end of the pipe" issues of water quality and social disadvantage (Martinez-Alier et al., 2010), understanding "social metabolism" as the manner in which human societies organize their exchanges of materials and energy with the environment (Fischer-Kowalski, 1997; Martinez-Alier, 2009).

Methodology

It has been essential for the research to combine quantitative and qualitative data in order to develop an integrated solution. The fragility of the ecosystem and the necessary participation of the community in this process require a specific methodology that incorporates fieldwork and secondary analysis. The challenge of working with little or no existing data has required extensive data collection by the author, using advanced mapping techniques of GIS (Geographical Information System), field observation, site analysis, and a community survey.

Figure 1 Site Map: Satellite image of Cuba 2012.The Palma Soriano research area is located in Southeastern Cuba, in the Sierra Maestra Mountains, headwaters of the Cauto River (Source: - Google Earth)

The Community

The city of Palma Soriano is located in the foothills of the Sierra Maestra, at the headwaters of the Cauto River (Figure1-Site Map). Palma Soriano is the biggest city in the Cauto, with approximately 124,000 habitants. The upper portion of the 230-mile River, including Palma Soriano, is home to poor and marginalized communities of Afro-Haitians who began settling here after the abolition of slavery in Haiti in 1868 (Nunez Jimenez, 1998).

The spiritual and artistic centre of the Palma Soriano community is Ennegro. Ennegro is an Afro-Haitian environmental art group that sees a sacred relationship between ecology and

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religion, giving spiritual values to the landscape. They believe their ancestors' spirits and gods live in the native forest and that it is therefore extremely important to keep rivers and streams clean and in continuous movement (Thompson, 1983). The spiritual frame of reference extends to the cultivation of their land and the integration of human activities into the natural environment.

Ten years ago the Cuban Government gave Ennegro a piece of land upstream from the city, at the intersection of two tributaries, which, together, form the Cauto River. The community had worked for years to obtain this land, reflecting their cultural agreement that this land was a sacred and life-giving place. According to Martinez-Alier (Martinez-Alier et al., 2010) "sacred places" for a particular community require just such a cultural agreement. It is on this land Ennegro is planning an agrarian spiritual community, where culture and traditions would combine in the cultivation of their own land.

The community is proposing to build upon a Vatn concept, which proposes to transfer a market economy to non-market domains (Vatn, 2000). The responsibility for care and management of the environment in which they live would become that of the local community, with their own production within the public domain. This opens the possibility of a socially responsible restoration of the Cauto that has been critically damaged by agricultural exploitation in favour of coffee and sugar during the last centuries (Scarpaci & Portela, 2009).

The recent economic and cultural transformation of Cuban society from a centrally controlled socialist economy into a new model of more independent private initiative has not been a smooth transition, particularly for marginalized communities like Palma Soriano, which lacks access to foreign capital. In addition to deteriorating public health and quality of life, absence of public transportation, limited food variety, and unstable energy support, the city has serious problems with its potable water system. The municipality provides domestic water from the Cauto River in a discontinuous system with erratic deliveries. The water quality is poor with high levels of microorganisms that cause serious health problems in the population despite high levels of added chlorine. Cholera is not unknown in spite of public health efforts such as sanitizing person's hands and feet before entering public buildings.

The proposed wastewater treatment project addresses water pollution and its associated problems by following a holistic integrated-based ecological approach consistent with the cultural identity and values of the local community. There are clear linkages between the poor water quality in Palma Soriano and the ecological balance in the Cauto. The project proposes a natural cycle using the sun, gravity, plant life and fisheries as elements to clean the effluent, thereby taking advantage of the cultural values that Ennegro has been cultivating for years and the spiritual cultural heritage of the local population. The public wastewater treatment project empowers the local community with social environmental responsibility and provides them an opportunity to integrate urban agriculture and natural restoration of the borders of the Cauto by using recycled water for aquiculture, irrigation of fruit trees, and the restoration of the riparian forest of the river. That Palma Soriano is the "Sister City" of Berkeley, California with whom it has an on-going cultural exchange opens the possibility of the citizens of both cities contributing to the project together. In 2012 Berkeley's mayor and state senator visited Palma Soriano to encourage this cooperation.

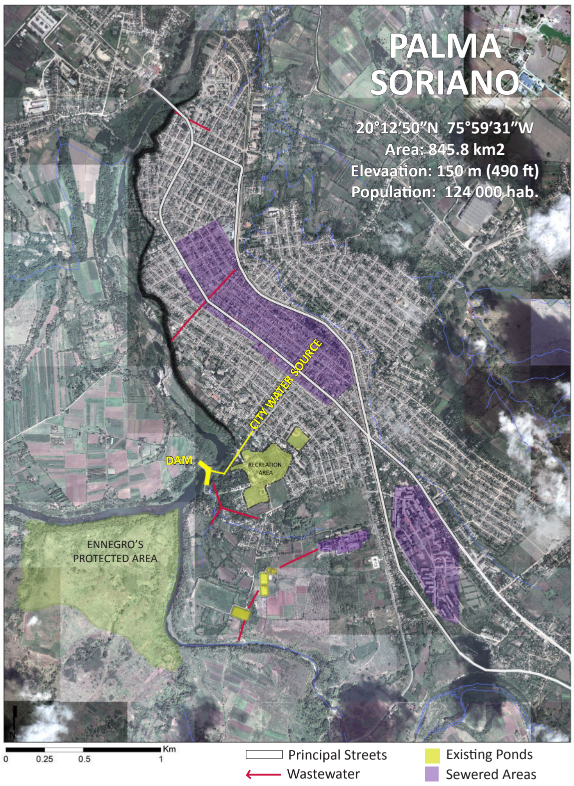
The ecological degradation in Palma Soriano is a result of narrowly conceived single purpose “urban development”, which has caused extreme damage to the natural environment and severe harm to the urban community. The Cauto River and Palma Soriano is just one example of this common phenomenon found throughout the world. The agricultural exploitation since the 18th Century has left a profound impact on the local landscape and culture with the loss of nearly 87.5% of island’s forest (Scarpaci & Portela, 2009) and the uncontrolled desertification of the of the Cauto River watershed. Population growth and development have reached a critical point in the community’s relationship with the environment.

As is true in much of the world, “development” has led to cycles of destructive environmental changes in ecological processes, which threaten humanity (United Nations General Assembly, 2000). Water quality, deforestation and the unhealthy extension of urban areas are examples of this damage. As a result, social and economic suffering has increased in developing nations, as exemplified in marginalization and poor living conditions for vast numbers of people (United Nations General Assembly, 2000). This is why the purpose of this project is to provide an example of how a healthy relationship between the city and its water source can be restored by a community work and the cultivation of their own land.

The problem

Raw sewage from Cauto River urban settlements flows directly to the river, contaminating their only water source. This not only degrades the surrounding ecosystem but also threatens public health. For example after the Hurricane Sandy in 2012, numerous outbreaks of cholera occurred. This problem has led to several damaging consequences not only to the environment but also to the health of the population, as the river is both the source for potable water and simultaneously the sink for wastewater.

The polluted drinking water has caused the spread of disease and in some cases death within the community. Many people treat the polluted water by boiling it before consumption. Wood is collected from the riparian forest of the Cauto River for fuel. As a result of decades of this process and high agricultural production, the borders of the Cauto River are now severely deforested. The deforestation has led to an increase in sediment input and the degradation of the river’s ecosystem. It is very difficult to control the illegal deforestation and this practice will likely continue if no alternative is provided. The water cycle of Palma Soriano is certainly not helping to this problem (Figure 2 - Palma Soriano’s associated problems). Wastewater coming from industry and housing runs directly into the river where it is retained behind a small dam to be pumped to the city for consumption. Deforestation compounds the problem by instigating soil erosion which get washed into the river, further impairing water quality. Deforestation and the contaminated water lead to unsafe conditions for use of the natural areas around the river normally used for swimming, fishing, and food collection. The local Afro-Haitian community is especially concerned about the degradation of water quality in the Cauto River and they have asked for international support. The local problems provide an opportunity to



Figures 2 Palma Soriano's associated problems: Contaminated wastewater runs from the street directly to the Cauto River contaminating the sole water source for the city and the main public open space for people (Google Earth Satellite Image 2012 edited by the author)

develop design solutions that integrate social and environmental issues for a community in need of help.

It is important to understand that in Palma Soriano people live under very poor conditions. Several families may live in a two bedroom house, with just one latrine and often without electricity or potable water. Public transport is almost non-existent and people struggle for food and economic opportunities. It is crucial to resolve water quality problems by providing treatment of wastewater before it returns to the river in order for the community to survive at a reasonable level of quality of life.

What is the best solution? Conventional water-treatment facilities are multimillion-dollar highly engineered facilities (Yang 2006). They are designed with minimal regard to their environmental impact and their dependence upon energy and raw materials. These systems generate by-products and pollutants during treatment (e.g. waste sludge, waste gases, and waste chemicals) and have a high operational cost (Yang 2006). The environmental by-products and cost make it impossible to implement such facilities in Palma Soriano, where the cost and consumption of energy must be held to a minimum. A traditional, engineered treatment facility is not viable for this community due to the economic condition of the city and its poor energy supply. Palma Soriano requires a solution that is inexpensive to maintain and operate and will provide multiple benefits in addition to increased water quality.

Proposed solution

This project proposes to treat the discharge to the river with a natural water treatment facility in order to improve the quality of drinking water for the community and to mitigate the impacts of deforestation of the riparian forest. Additionally, the project proposes to provide opportunities for environmental education and community engagement with the environment in the context of changing the social metabolism. Because on the conflict "at the end-of-the pipe" are enormous amount of opportunities, nutrient and energy that we must to simply tap within agriculture and forestry or by other appropriate technologies (Martinez-Alier et al., 2010).

Natural Water Treatment, as an alternative to the traditional highly engineered approach, uses the same quantity of energy as conventional systems. However, the energy is provided from natural sources such as solar energy and gravity flow, which keeps the water in movement and promotes the natural biologic process of purification and decomposition (Marrero 2008). There are different systems of natural water treatment such as aerated lagoon, bio filters and constructed wetlands. A complete process of wastewater treatment should integrate primary, secondary and tertiary treatment units (Drechsel, Scott, Raschid-Sally, Redwood & Bahri, 2010).

A primary treatment unit would remove suspended matter. Where wastewater has a high number of pathogens, primary treatment can remove a substantial number of pathogens (Drechsel, Scott, Raschid-Sally, Redwood & Bahri, 2010). Secondary treatment systems, which follow primary treatment, are biological treatment processes coupled with solid/ liquid separation. Tertiary treatment refers to treatment processes downstream of secondary treatment, which filter and disinfect the water. Filtration is also an effective additional step for removing pathogens (Drechsel, Scott, Raschid-Sally, Redwood & Bahri, 2010). Recent studies of biogeochemical cycles indicate the important role of wetlands in natural cycles of organic and inorganic matters (Marrero 2008). Because wetlands have a higher rate of biological activity than most ecosystems, they can transform many common pollutants that occur in conventional wastewater into harmless by-products or essential nutrients that can be used for additional biological production.

Understanding the biological processes behind water treatment provides an opportunity to think about human integration in this process of decomposition. It opens up the possibility of thinking about the relationship between production and waste in order to rethink and redesign the cycle of human consumption. For example, the rich quantity of nutrients that are a by-product of the treated wastewater could be used to nourish soils and plants. Using these nutrients could improve food production and return essential nutrients to the environment. It is from this perspective the Palma Soriano Wastewater Treatment plan was born. By establishing a new water cycle, where the organic materials of the wastewater could be integrated into and benefit the environment and the treated wastewater used for irrigation, a treatment facility could promote food production in the area, restore the highly-eroded soils at the borders of the Cauto River and support reforestation in the riparian zone of the river.

Key to accomplishing this is the

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conscience and environmental education of the local population. Applying the principles of local economic development based on solidarity, support and sustainability, the proposed project has been developed to help the local community restore the essential ties that link their lives with the world we inhabit. Moreover, this project aims to improve people's diet and increase the opportunities for urban food production. Public space and open areas should integrate the sense of belonging, respect and oneness with the land in order to create new generations who will care for the environment and appreciate the consequence to their own health and well-being if they fail to do so. Food production should be the result of that this relationship between humans and their environment. As Carlo Petrini expresses in the Manifesto of Future Food "They are important and strategic factors in human nutrition, in the delicate balance between nature and culture that underpins our very existence. Food communities are the expression of human labour: in the sector of agriculture, animal breeding, fishing, herding and food processing. They are also the expression of the earliest human interaction with nature: cooking" (Shiva, 2007).

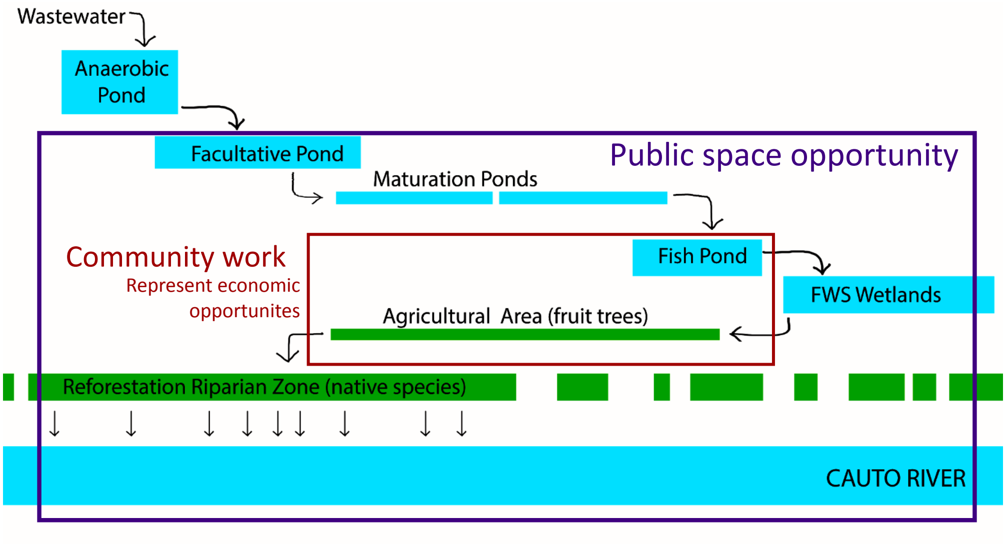
Establishing a sense of community and growing things are essential characteristics for a sense of well-being. Restoring a water cycle that integrates human activity and natural processes is the basis for the construction of a better future.

However, the solution cannot come from the outsider but from the hands of the local community. That is why I am proposing a natural treatment system which will integrate the local community with their surrounding environment through their participation in the construction of a new, natural way to solve their problem (Figure 3 - Concept diagram of the Master Plan Idea). As an added bonus, this will include opportunities for the cultivation of their own land, improvement of the soil, and the restoration of the native forest in a strategic eco-park which will encourage people to have a profound spiritual identity with in the natural landscape and food production consistent with their traditional belief system.

The proposed wastewater treatment system has multiple benefits. A pond system and a constructed wetland will be used to treat the city's wastewater and storm water. After the wastewater has been treated, water will be directed into a pool that can be used for aquaculture. The community will be in charge of maintaining this system and can use the aquaculture as a source of food for their pigs, the main source of livestock consumed in the community.

Additionally, the wastewater treatment design incorporates a reforestation component. As part of the tertiary system, the treated water will be used to irrigate riparian vegetation and fruit trees. The riparian vegetation will provide habitat for wildlife and improve the ecology of the watershed. The fruit trees will provide additional habitat for wildlife as well as provide a source of food for the community.

It is critical to keep the community engaged with the project to ensure its long-term success and the sustainability. The ponds must be maintained and cleaned from time to time. To ensure the community's engagement, the community will be involved in refining the final design, constructing the project and managing the system. The fruit orchard and aquiculture system will



Figures 3 Concept diagram of the Master Plan Idea (Image created by the author)

provide additional incentives for the community to become involved in maintaining the system. If successful, communities both in Cuba and elsewhere can employ the project's low cost, yet effective methods. Any environmental protection and ecological design solution necessitates a healthy relationship between humankind and nature, and will foster environmental education and preserve cultural identity, which are the essential values for sustainable development.

The Master Plan Design

The master plan proposal (Figure 4 - Master Plan Proposal & Site Location) integrates all the proposed solutions into one overall project. The master plan provides a macro scale solution for the city of Palma Soriano. Although each individual component of the master plan could be seen as an independent project, the overall success and function of individual components truly depend on implementation of the entire master plan. This includes a new source of up-steam water and a new sewer system that permits drainage of wastewater to an area that will provide natural wastewater treatment. Fortunately, the municipality of Palma Soriano has already proposed plans to implement a new source of up-stream water and a new sewer system are part of a proposal entitled, "Saneamiento y Sanitisacion para Palma Soriano".

This project addresses the need for a natural wastewater treatment facility and reforestation proposed in the master plan. The New Wastewater Treatment Project (Figure 5- Schematic Design Project and Programming Location), includes a (a) Wastewater Treatment Ponds, (b) a Fish Pond, (c) a Wetland, and an irrigation zone of (d) Fruit Orchard and (e) Reforestation of the Riparian Zone. The area of natural wastewater treatment is divided into three stages of treatment: primary (a sedimentation and facultative pond), secondary (maturation ponds) and tertiary (a fish pond and constructed wetland). Treated water will be used for irrigation of a community fruit orchard

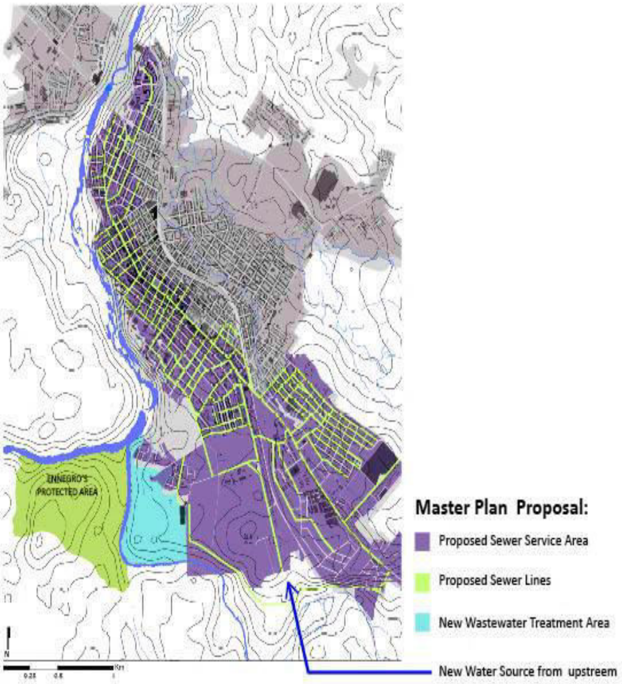


Figure 4 Master Plan Proposal & Site Location: Map developed by the author using a DEM (Digital Elevation Model) to build topographic data of the area. Image shows the 5 meter contour lines constructed. DEM source: Jet Propulsion Laboratory of the NASA (http://www2.jpl.nasa.gov)

and in the proposed reforestation area. Finally, the master plan locates and designs a pedestrian path that integrates the project into the surrounding area and provides an element of human experience.

Project parts

New Source of Water Upstream

The city of Palma Soriano needs to access an upstream source of water. The primary objectives of this new water source will be to provide to the city with fresh water and a continuous flow to replace its current polluted source from a stagnant pond formed by a dam which will be removed to allow the free flow of water.

New Sewer System

The city of Palma Soriano needs to update their old sewer infrastructure, and extend sewer service areas to the entire urban area. This expansion will control excess wastewater draining into the river and streams. The alignment of the pipe system is based on the natural slope-drainage and provides sewer services without requiring complex engineering solutions and thus the project includes a design of a new sewer system for the city.

Natural Waste water Treatment:

From the base of the sewer system and the water coming in from serviced areas, it is possible to design a natural treatment system that digests organic matter through the biological process of degradation. The first two ponds function to encourage sedimentation of solid sediment and start the process of organic composition that is the function of the next two maturation ponds. A shallow depth of the pond will allow more sun light penetration to the water and facilitate photosynthesis from the algae.

Figure 5 Schematic Design Project and Programming Location (Author's drawing)

Fish Pond

After the sequence of maturation ponds, a fishpond would generate an aquaculture. Aquaculture techniques are used to feed populations without taxing natural fish populations. By integrating a fish pond that can be managed by the local community giving them products from water treatment; and integrating economic opportunity for the community and an essential food source.

Constructed Wetland

The final element of the proposed master plan involves the construction of a wetland area. Wetlands are beds of aquatic life that grow in soils or, more commonly, sand or gravel. They provide wildlife habitat and have a strong capacity to support nesting and feeding of birds. The principal species proposed are based on native, non-invasive species in Cuba. Finally the design and area of the wetland should integrate not only wildlife and hydraulic functions, but also include an interesting design that permits interaction of people with the place and engagement of people with the wastewater system.

Community Fruit Orchard

An additional element was added in order to construct a space for the community and to direct effluent water from the treatment system towards locally supported agriculture. This designated are will be a community fruit orchard. This Treated wastewater has high levels of nutrients and is therefore appropriate for irrigation of agricultural fields. Community involvement in this project will allow locals to understand how their food needs and waste disposal practices can be intricately linked to the surrounding ecosystem.

Reforestation Area

The plan proposes to irrigate an area of low dense forest and deforested patches in order to restore the Cauto River's native riparian forest. This area is located on the border of the river and the reserve area of Ennegro. The native riparian forest restoration project will restore the native ecosystem of the river, create a barrier between the urban area and the protected area and provide open space to the local community.

Design the Path: Access to the River and Public Spaces

The design of access and public spaces for people to interact with the restored area will encourage community participation with the treatment system and surrounding ecosystem.

Conclusions

Creating equilibrium between societies and the environment is very challenging and water management is an essential factor in sustainable development (Yang, 2006). A natural water treatment system improves not only the quality of the water discharged, but also the quality of life for the surrounding community. In this specific case, local communities will directly benefit from the project as owners of the production are within the public domain and the public space proposed on the border of the Cauto River. The public project is located next to the protected sacred place of the Ennegro Community and it is designed for the local people of Palma Soriano. While the entire local community may not necessarily integrate Afro-Haitian beliefs into their daily lives, they have a strong Afro-Haitian heritage in their culture which welcomes and supports restoration of the natural water cycle in Palma Soriano. The cultural perception of nature in the local community has certainly influenced the environmental conflict (Martinez-Alier et al., 2010) and the final design solution. Community engagement and local support are both key factors to the success of the project.

Reforestations plans integrated with agricultural systems have great support from this local community. This integral approach and holistic perspective of the problem will help move the project forward. It is essential to think of solutions that integrate people's interest and provide them new opportunities to improve their quality of life. Public spaces are essential spaces in cities and should integrate natural environmental conditions as well as human necessities. The sense of belonging, respect, and domain of the land, which cultivation activities produce, is highly important (Heidegger,1951); and urban agriculture and community reforestation processes are a successful ways to provide them.

The master plan proposed provides essential elements to help initiate this project. With the participation of international NGO's, the Green City Fund, and the strong interest of the community this project is moving to the next stage of development. Community education and community motivation on the development of the project are key factors. This project is an example of a sustainable solution for Palma Soriano and I believe the community of Palma Soriano and the local group, Ennegro, have the capacity, motivation, and power to make this happen. Urban agriculture and aquaculture are the main incentives of locals to participate and integrate into the project. These activities provide economic and subsistence opportunities. Moreover the restoration of the natural ecosystem of the river will return to the city the opportunity to use the Cauto River as its main open space. Furthermore the project will provide a healthy recreational space for adults and children to enjoy and learn about their environment. It will stimulate environmental education and enhance the Afro-Haitian spiritual values and respect for the place they inhabit.

Community gardens and participatory reforestation are the most successful ways by which the local community of Palma Soriano can be empowered by the project. The Palma Project should serve as an example of an approach that can be used to solve similar environmental and social problems elsewhere and provide a methodology for problem solving that could be replicated in other areas of the world. As Vadana Shiva states (2007): "*…drinking water is already scarce in many regions of the world, and we must make sustainable freshwater management a priority*". A sustainable water-management plan must also stop the ongoing soil erosion to preserve the basis of agricultural production and must phase out the alarming input of toxic substances into vital ecosystem as well as the human food chain" (Shiva, 2007). Moreover Shiva points out that agriculture and traditional food production systems are an integral aspect of cultural identity and all human communities have the right to preserve and further develop their diverse cultural identities (Shiva, 2007).

The case of Palma Soriano and the important Afro-Haitian Community is just one microcosm exhibiting the relationship that could be constructed between culture, environment, and food production. If this project is successful, these methods could be used to improve water supply and sanitation in other disadvantaged and impoverished communities, where cultural identity needs to be recognized and validated in order to approach a sustainable solution for the community and their habitat. This affirmation will raise the question of the problem-solution for the conflict at the "end of the pipe" in multicultural and globalized cites. Cities where local solutions and local opportunities blur in a huge economic system. It is a solution that can take over essential and humanistic ways of connection between humans and their environment. In this way, water management, and specifically wastewater treatment, would be a solution to bringing together communities in a common territory, reclaiming a clean environment, and promoting a respectful and conscience social metabolism of exchanges with the environment (Fischer-Kowalski, 1997; Martinez-Alier, 2009).

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Related Links

• Video: “Palma: The Story of a People”: https://vimeo.com/60928823

• Palma Soriano Project: http://dcorvillon.com/environmental/palma.html

Indigenous Knowledge (IK) of Water Resources Management in West Sumatra, Indonesia

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Abstract

This study aims to describe the indigenous knowledge of farmers at Nagari Padang laweh Malalo (NPLM) and their adaptability to climate change. Not only is water scarcity feared, but climate change is also affecting their food security. Local food security can be achieved if biodiversity in their surrounding area is suitable to the local needs. The study was conducted by using Participatory Rural Appraisal (PRA) such as observation and discussion. The combination of in depth interview, life history, semi structure questionnaire, pictures, mapping and expert interviews was implemented. Data was analyzed by using MAXQDA 10 and F4 audio analysis software. The result shows that the awareness of the people and scarcity of water conditions has allowed the people of NPLM to face this challenge with wisdom. Aia adat (water resources controlled and regulate by custom) is one of their strategies to distribute the water. The general rule is that irrigation will flow from 6 pm – 6 am regularly to all farm land under supervision of kapalo banda. When rains occur, water resources can be used during the day without special supervision. They used traditional knowledge to manage water resources for their land and daily usage. This study may be helpful for researchers and other farmers in different regions who encounter water scarcity.

Keywords: *Micro-climate changes; Traditional water management; West Sumatera*

Introduction

Water scarcity is one of the most pressing development challenges of the early 21st Century. According to securing water for food.com (2013) approximately 2.8 billion people—more than 40 percent of the world's population—live in river basins impacted by water scarcity. Nearly half live in areas of physical scarcity, where demand is greater than the available supply; the remaining 1.6 billion face economic water scarcity, where institutional, financial and human factors limit access to water despite an available natural supply. According to FAO (2012), agricultural water withdrawal accounts for 70% of total global water withdrawal. The assessment went on to estimate that up to two-thirds of the world's population would be living in water stressed countries by 2025 (Arnell, 2004).

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Climate change according to Intergovernmental Panel on Climate Change (IPCC) is refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC, 2007). Changes in extreme temperatures have been observed. Furthermore, the IPCC in Working Group I explain that global average surface temperature rose 0.6°C, over the 20th century, total sea level rose 0.17 m in the 20^{th} century and Arctic sea ice decreased 2.7% per decade since 1978 and the maximum area covered with frozen ground has decreased by 7%. The consequences of this, intense tropical storm and hurricanes as well as longer droughts occurring in tropical and subtropical are including in West Sumatra, Indonesia. Unpredictable and slight changes of climate affect farming systems, local people and water availability.

Water demand management is defined as any actions that reduce the amount of water used or enable water to be used more efficiently (Brooks, 2006); hence, the term water conservation is often used synonymously with water demand management (Baumann et al., 1998). According to Russell and Fielding (2010), some expert adopts the term "water conservation behaviour" to define and measure the broader concept of water demand management. Using Stern (2000) as a guide, the determinants of water conservation behaviours can be categorized into five underlying causes: attitudinal factors, beliefs, habits or routines, personal capabilities, and contextual forces.

Over decades farmers and indigenous people wisely adapt to any changes, including changes of their local environment. Indigenous knowledge of societies is accumulated over historical time and it is a belief system stressing respect for the rest of the natural world, furthermore evolving sustainable relations with the natural resource base (Oldfield, 1991). Many indigenous societies depended on a rather limited resources catchment of a few hundred square kilometers to provide them with a wide diversity of resources (Gadgil, 1993). Indigenous knowledge is herein defined as a cumulative body of knowledge and beliefs handed down through generations by cultural transmission about the relationship of living beings and their environment (Berkes, 1993).

This study is an excellent example that illustrates the practicality of local indigenous knowledge and the managing of biodiversity and natural resources. People in Nagari Padang Laweh Malalo (NPLM) are called Minangkabau. The mother plays a role from production until preserving the food. The interesting motivation of the Minangkabau`s is that they maintain their water resources in unique ways to achieve food security for themselves.

According to Carol et al (1988) who conducted research in Minangkabau she concludes that still there are a lot of aspects that can be elaborated concerning indigenous knowledge in agriculture system in Minangkabau based on the local agro-socio-cultural situation. The predominant focus is on the local level and what indigenous knowledge can contribute to a local sustainable-development strategy, potential, experiences, and wisdom. The aim of this study is to describe the indigenous knowledge of farmers at Nagari Padang laweh Malalo regarding their adaptability to climate change especially encounter water scarcity.

Methodology

The data collection method is Participatory Rural Appraisal (PRA) which is comprised of qualitative and quantitative data collection. The combination of in depth interview, life history, semi structure questionnaire, pictures, mapping and expert interviews were implemented. Data was analyzed by using MAXQDA 10 and F4 audio analysis software. The visit was done two times. A total 53 farmers between the ages of 22 – 73 years old were interviewed. Men and women are randomly interviewed. Interviews were started with the head of the clan and continue to groups of farmers and then households.

Result and discussion

Household characteristics

Based on interviews and investigation, the clan of *Sikumbang* had the largest land in comparison to other clans; *Chaniago*, *Koto*, and *Piliang*. *Minangkabau* is the widely spoken language among all clans. Farming is the main activity. A typical household characteristic according to our investigation is consisting of a father, mother and children (n=53) with a ratio of male to female being (1:1). The families investigated had a monthly income US$ 55.5 (n=16), US$ 55.5- US$ 111.1 (n=21) and more than US$ 111.1 (n=12). Most of them were farmers (n = 27), traders (n=13) and civil servants (n=3). They have side jobs such as livestock breeding (n=13), *lapau* (coffee shop) (n=1), *ojek* (motorcycle as public transportation) (n=2), woods trader (n=1) and fishermen (n=3). Land status is clan ownership (n=24), family ownership (n=6) and father ownership (n=2) and rent (n = 1). The families investigated have less than 1 ha (n=24), 1 ha –2ha (n=7), and 2 ha-5 ha (n=1). Since most of the lands (n=30) are under clan ownership therefore only (n=1) a farmer could show evidence of ownership. The clan's ownership has less freedom in managing the land rather than individual ownership.

Topography characteristics

Every year in West Sumatera (0º29'38'' and 0 º 35'30'' South Latitude 100 º 22'36'' and 100 º 31'44'' East Longitude) monsoons occur two times with peaks season in March and December. The lowest precipitations are in June and July. The maximum averages of precipitation reach 4000 mm per year, especially on the west coast and east of West Sumatera; the minimum average of precipitation is around 1500- 2000 mm per year. Diversity in soil and climate may lead to the diversity in cultivation (Ultisols, Inceptisols, and Entisols). The crops are grown also diversely from one site to the other (Soil Survey, 1999).

There many stones on the farmland which is typical of soil closer to volcanoes; located between Mt. Marapi and Mt. Singgalang. The stones often damage the farmer hoes. There other typical soil is Andisols, which has andic soil properties of 60 percent of the upper layer with one outstanding features of high natural productivity.

The water sources are coming from hills adjacent to the farmland. The spring used for irrigation of the rice fields, is also used for household activity. There are at least 18 springs, some of them merging to form a larger flow. The water resources come from several springs such as: *Aia Situngka Banang, Sungai Baliang, Bigau, Aia Batuang, Batu Hampa, Aia Ubun-ubun, Sungai Rak Ilia, Batang Lasia, Muaro Buluah, Aia Lalu, Pincuran Lubuk, Siku Banda, Sawah Jambak, Sungai Pakak, Aia Sawah Dukik, Umpia* (which is used as a source of drinking water in a clean water program). When the dry season comes, most springs will run dry even with a maximum annual rainfall of 4700 mm.

Indigenous knowledge of water resources management

Topographically this location experiences cloudy condition daily, the winds come from the top of the hill, north east of the NPLM. Interestingly, there is not enough rain pouring to the farmland even though data shows an annual rainfall is 4700 mm, the rain largely fall behind the hill. The people describe this phenomenon as "shadow of the rain area" (fig. 1a). Despite this high annual rain falls, the particular valley where they live does not benefit because the topography diverts water flow into adjacent regions. However, there are also some advantages to this local micro-climate. The dry wind blowing from the top hill creates conditions in which pests and plant diseases cannot survive.

This seasonal and predictable phenomenon provides the people with a water resources management strategy. One example of a traditional farming approach is that, in some places the irrigation system is managed by the *adat* (custom) (fig.1b). One person is chosen as *kapalo banda* (the head master of irrigation) to manage the system. The traditional irrigation systems are strictly managed by ninik mamak (indigenous elders), which are directly appointed *kapalo banda* (which regulates water sharing during the night – irrigation).

Aia adat is used only for paddy cultivation, with accordance to the quota; if there is a violation of the rule, customary sanctions are used to punish the guilty parties. The land will be watered at night from 6 pm until 6 am in the morning; people are not allowed to see the water flow. There is a punishment if somebody tries to break the rule. A similar study in Mali done by Vandersypen et. al. (2007) revealed that in conflict on water management issues, a mediator is often called upon to make a decision. Conflict management follows pre-eminently informal patterns and passes through different steps. In the first step, the mediator is an influential farmer of the tertiary block, who may or may not be the canal chief. Most of conflicts are settled at this level. If no agreement could be reached, an influential person at the village level is contacted. The village chief can either take a decision himself (five villages) or call upon someone he judges to be more competent on the matter, such as the water bailiff, to whom he lends his authority (two villages). A study about optimal water management and conflict resolution was done in a Middle East water project by Fisher et.al. 2002 and revealed that a model that has been developed is called ''WAS'' for ''Water Allocation System'' is a model for the Israeli-Jordanian-Palestinian region. Such models can assist the formation of water policies, taking into account user-supplied values and constraints. They provide powerful tools for the system-wide cost-benefit analysis of infrastructure.

Local awareness of the scarce water conditions has allowed the people of NPLM to face this challenge with wisdom. *Aia adat* (water resources controlled and regulated by custom) is one of their strategies to distribute the water. Indigenous knowledge of water resources creates planting time accordance to the fluctuation micro-climate as shown in graph 1 below.

They have to maintain the schedule in order to water all the land fairly. They are maintaining the work together as well. There is a meeting among farmers before cultivation time begins. The meeting is to discuss when, each piece of land is to be cultivated or harvested, and to whom the work should designated. Rice is normally cultivated in *tahun* *gadang* and takes fourteen months for cultivation. The crop rotation is based on *tahun gadang*; rice planted as monoculture, with no intercropping occurring (14 months with 3 times the rice harvest). The crops were rotated every third year, for example, Rice-Peanuts-Corn or Peanuts-Rice-Corn. They are aware that rotation makes increase in soil fertility.

A similar study was done by David (2011) revealed that those villages with higher biodiversity is due to the awareness of their local people. The loss of a traditional farming system is the most common situation; the highest local biodiversity is related to the local wisdom in using their natural resources. Related studies about food insecurity explain that people tend to spread the risk of food insecurity by increasing revenue, either from agricultural activities (collected forest products), excluding farming, or other activities (Niehof, 2010). But in this area, people tend to face their food insecurity by finding the problem (in this case water scarcity) and solve it communally.

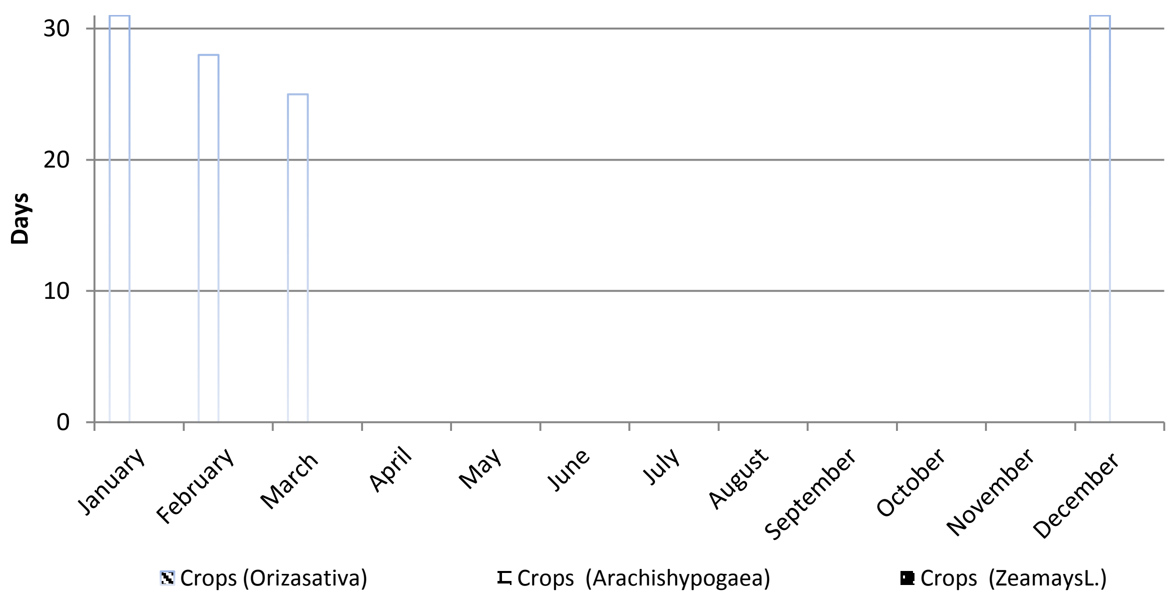

Figure. 1 Crops rotation in *Nagari Padang Laweh Malalo (Appendix with clear illustration)*

According to the survey, traditional water resource management of people at NPLM provides sustainability of rice production based on *tahun gadang* calenders. The daily household food intake revealed that they eat rice (n= 53) 2-3 times a day. Protein intake is from fish (n=17), egg (n=7), meat (n= 16) and other (including eel) (n=13). Vegetables intake are from cucumber (n=13), cassava leaf (n=32) and jackfruit (n=8). Fruit daily intake are from banana (n=25), papaya (n=24) and watermelon (n=4). Local Health Center reported, the nutritional status of this area is classified as well nourished. Up to now, there is no case of child malnutrition.

Figure 2 (a) Shadow of the rain area phenomena, (b) small creek to watering the farmland

Conclusion

The study revealed that farmers are practicing indigenous knowledge regarding their topographical disadvantageous. They created *aia adat* regulation to watering their land fairly, bringing benefit in terms food security. The above findings may be helpful for other farmers as well as researcher to learn from the wisdom and techniques. The study may help the improvement of livelihood of the rural farmers of this district. These traditional knowledge based practices of this area are low cost and more profitable for farmer under water scarcity.

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Appendix

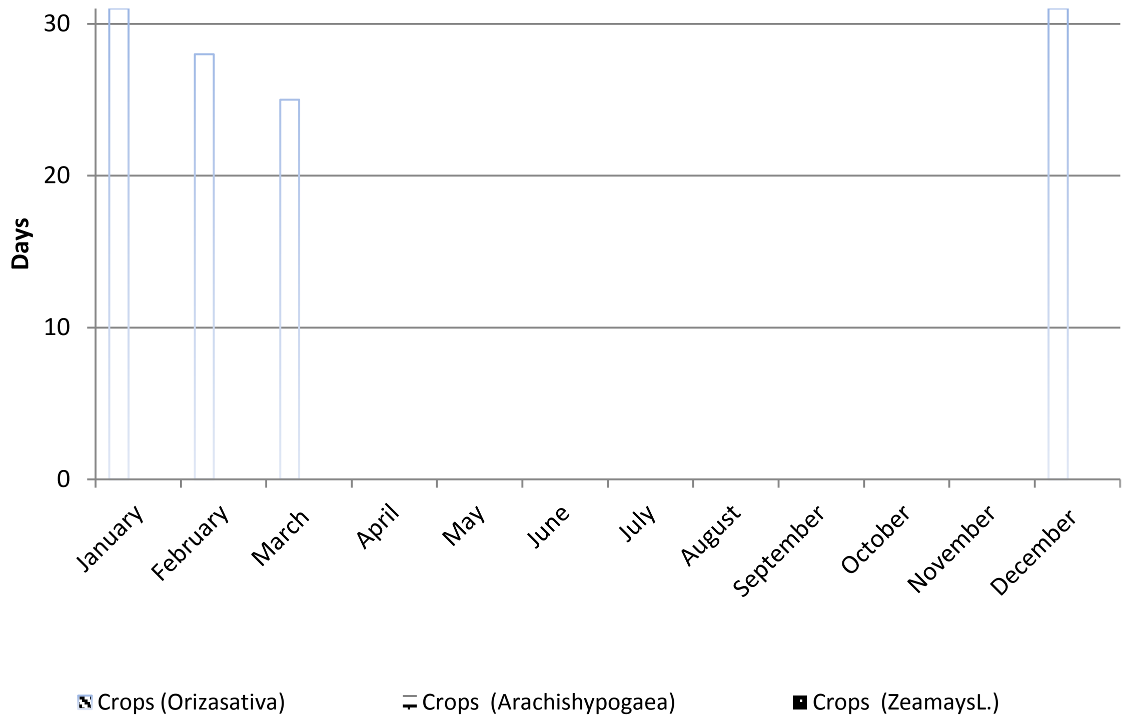

Figure. 1. Crops rotation in *Nagari Padang Laweh Malalo*

Figure 2: (a) Shadow of the rain area phenomena, (b) small creek to watering the farmland

Water Resource Pollution and Impacts on the local livelihood: A case study of Beas River in Kullu District, India

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Abstract
Rivers are considered as the life line of any country since they make water available for our domestic, industrial and recreational functions. The quality of river water signifies the health status and hygienic aspects of a particular region, but the quality of these life lines is continuously deteriorating due to discharge of sewage, garbage and industrial effluents into them. Water demand has increased manifolds due to the increased population, therefore tangible efforts to make water sources free from pollution is catching attention all across the globe. This paper attempts to highlight the trends in water quality change of River Beas, right from Manali to Larji in India. This is an important river in the state of Himachal Pradesh and caters to the need of water for Manali and Kullu townships, besides other surrounding rural areas. The Manali-Larji Beas river stretch is exposed to the flow of sewage, garbage and muck resulting from various project activities, thereby making it vulnerable to pollution. In addition, the influx of thousands of tourists to these towns also contributes to the pollution load by their recreational and other tourist related activities. Pollution of this river has ultimately affected the livelihood of the local population in this region. Hence, water quality monitoring was carried out for the said stretch between January, 2010 and January, 2012 at 15 various locations on a quarterly basis, right from the upstream of Manali town and up to downstream of Larji dam. Temperature, colour, odor, D.O. pH, BOD, TSS, TC and FC has been the parameters that were studied. This study gives the broad idea about the characteristics of water at locations in the said river stretch, and suggestions for improving water quality and livelihood of local population in this particular domain.

Keywords: *Competitiveness; Ecological; hygienic; vulnerable; anthropogenic*

Introduction

Degradation of rivers has become a serious problem around the world due to an increased level of urbanization. Though the causes leading to river degradation are diverse, disposal of solid and liquid waste, encroachment upon the river waterway and water extraction are some of the obvious causes of river degradation. Water security is emerging as an increasingly important and vital issue for India. Many Indian cities have started to experience moderate to severe water shortages, brought on by the synergistic effects of agricultural boom, urbanization and industrialization.

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The availability of freshwater resources is declining in India on per capita basis due to increase in population from 345 million during 1947 to 1130 million during 2007 in six decades. Depletion of available freshwater resources, falling ground water levels and deteriorating water quality are all posing a variety of challenges in managing India's water resources (MoEF, 2010).

The Beas River is one of the major rivers under the Indus basin. It originates in the upper Himalayas from Beas Kund near Rohtang Pass in Himachal Pradesh and flows in the east-west direction in Himachal Pradesh till it emerges in the plains near village Talwara in Hoshiarpur District of the Punjab State. The total length of its course up to Beas Dam at Pong is about 230 km. The catchment area of Beas River is about 12,560 sq. km out of which only 777 sq. km is under permanent snow. The rest of the catchment area contributes water on account of rainfall especially from the high rainfall zones of Dharamsala, Palampur and Kangra. The bulk of the discharge of this river is received between the months of June and October due to concentration of rainfall in these months. The average annual inflow of Beas River is about 14,800 MCM. The river is a tributary of Ravi. The exact location of Beas River is shown over the map of India (Figure, 1). Beas River is a lifeline of the people of Himachal Pradesh because it is an important source of fresh water supply and the agriculture.

The recent trends in increased human activities have impacted the water quality of this important river to a great extent. The level of sediments and pollution is increasing day by day and so the quality of the water is deteriorating. The problem of degradation of Beas River seems to lie on so called 'tourism and urbanization' with complete disregard of the environmental, cultural and religious significance of the river. This problem has resulted in the wake of widespread and haphazard tourism induced urbanization which is evident from the fact that between 1985 and 2006 the number of hotels in the valley increased from 10 to 600. The number of tourists increased from 11,002 to 67,132 between 1975 and 1991 (Gupta, 2006).

The Kullu, Bhuntar and Manali municipalities have failed to check pollution in the Beas. Local fruit markets at Takoli, Bandrol, and Patlikuhal are responsible for the unpleasant smell all around. The substantial part of sewage, solid waste trash and junk churned by certain resorts and house owners from tourist spots of Rohtang Pass, Solang, Old Manali, Aleo, Kullu and Bhuntar towns continue to end up in the surging Beas. The river Beas is getting polluted day by day as there is no proper planning for sewage disposal or the disposal of solid waste either. Heaps of untreated solid waste can be seen along the banks of river passing through these municipalities. Ram Rattan Sharma, a local resident and tour operator based out at Manali accepts that the tourism in the district has been declining for couple of years due to ever increasing level of pollution in the river and spread of solid waste along the roads. Another local tour operator Kundalal from the study area attributes the changing pattern of tourism towards Jammu and Kashmir as a result of lack of

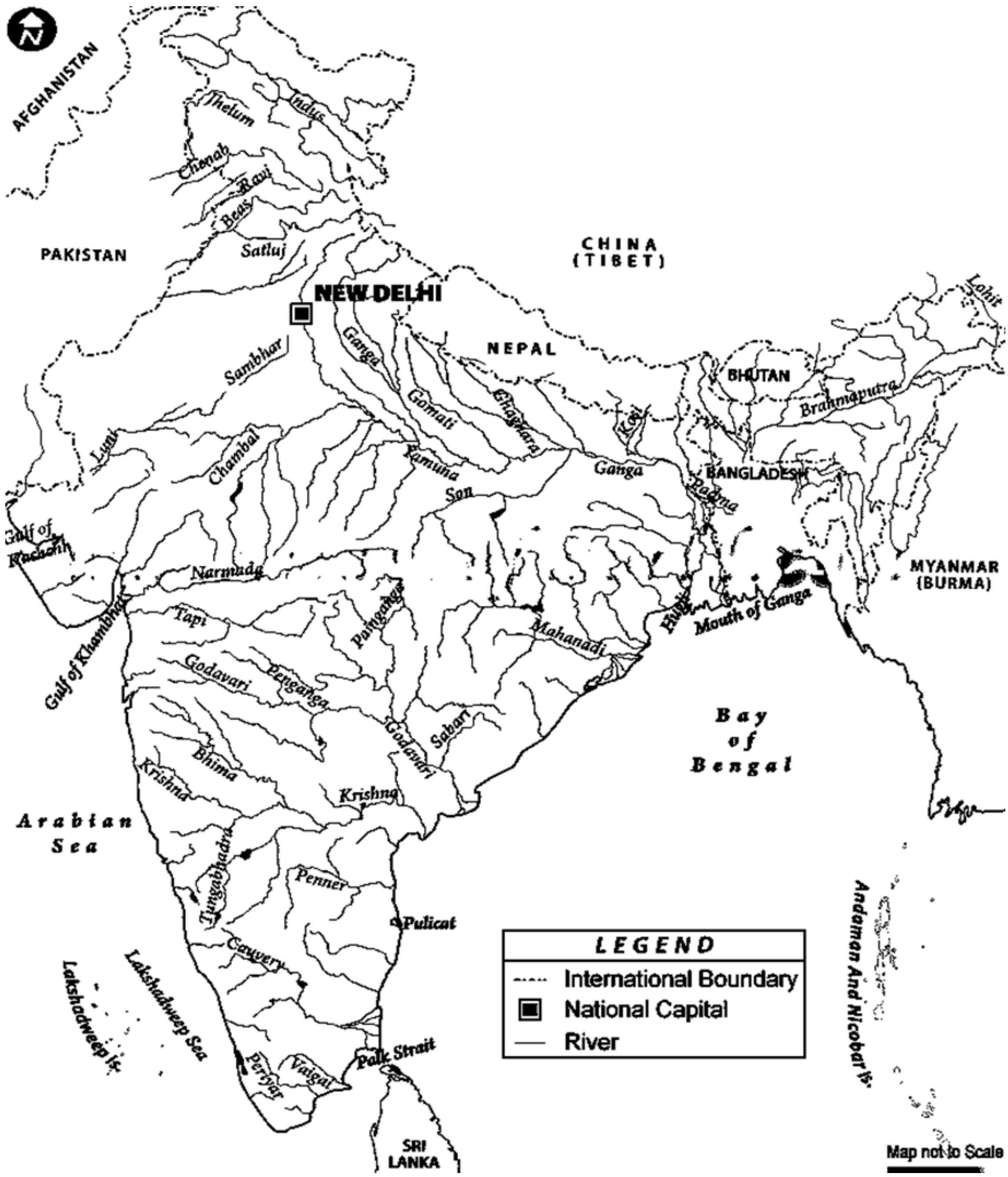


Figure 1 Map showing location of Beas River in the northern part of India

sanitation and pollution seen all across the river banks. The fishermen community that is largely dependent upon the fishing of snow water pomfret species of fish is also affected due to increasing level of pollution; Chaman Thakur of village Bandrol shares his experience of fishing in the Beas River over the years. As per talks with a fisherman by profession, Chaman Lal Thakur, the Pomfret species that is found in snow water downstream Manali has reduced drastically due to pollution of river and the increase in subsequent water temperature. The above observations inspired the authors to go for physico-chemical and biological assessment of the river water for a particular stretch between Manali and Larji Dam which is largely affected by pollution due to tourism activities and human habitation.

Figure 2 Map showing the exact location of the sampling points marked as tiny white circles over the red line depicting river in the valley
(Source: Non-Technical Summary, Environmental and Social Impact Assessment: 192 MW Allain Duhangan Hydroelectric Power Project, Tehsil Manali, District Kullu, Himachal Pradesh,February 2009, Page-2).

The district is situated between $31^{0}5'00'''$ North latitude and $77^{0}06'04''$ East longitude. The altitude variation in the district varies from 1,300 metres to over 6,000 metres from the sea level. The rock types found in the district are phylite, slate, quartzite, limestone, schist and granites (Balokhra, 1997).

Study Area

The study area comprises of Beas River from Manali to Larji along NH21 between upstream Manali town and downstream of Larji dam at 15 locations. The actual points of sampling for the study have been shown above the thick broken red line that shows the Beas River in the middle of the map (Figure 2). The study points were carefully chosen so as to get representative samples in order to interpret the impact due to sewage and solid waste dump into the river.

Methodology

To study the impact of pollution in Beas River, water samples were collected from 15 points in the Manali-Larji stretch from upstream Manali and up to downstream Larji Hydel project on quarterly basis from January, 2010 to January, 2012. The sampling points were selected at various vulnerable points along the stretch. As far as practicable, representative and homogeneous samples were collected from River Beas from the following points; Upstream (US) Manali, Downstream (DS) Manali, US Municipal solid waste processing facility (MSWPF) Manali, DS MSWPF Manali, DS Allain Nallah Confluence, DS Duhangan Nallah Confluence, US Kullu, DS Kullu, US Parvati river Confluence, DS Parvati river Confluence, DS MSWPF Kullu, US Fermenta Biodel, DS Fermenta Biodel, DS Aut and DS Larji power House. Allain Nallah Confluence and Duhangan Nallah Confluence were selected as one of the study points as these Nallahs carry the untreated sewage from nearby villages of Prini, Aleo and Jagatsukh. The pollution due to untreated wastewater from the tourist activities of Manali is seen reflected in the sample collected from DS of Manali. The physical parameters like temperature, colour, odour and pH were determined physically at site (Trivedi & Goel, 1984). The analysis for other chemical & biological parameters i.e. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Total Coliforms (TC) and Faecal Coliforms (FC) was carried out using standard methods (APHA, 1985) in the laboratory. The final results were analysed and interpreted following statistical methods.

Results and discussion

The results of the physico-chemical and biological analyses of the river water collected from the 15 location sampling points starting at US Manali to downstream Larji power house on quarterly basis from January, 2010 to January, 2012 were studied and are shown in graphical form. The typical physiochemical and biological conditions of the river have been represented through Table 1 to 4 (Appendix) that gives a fair idea of pollution existing in the river.

On comparing the analysis results (illustrated in Figure 3 to 8 for all the quarters over a period of 2 years from 2010 to 2012) the following parameter wise interpretations can be made.

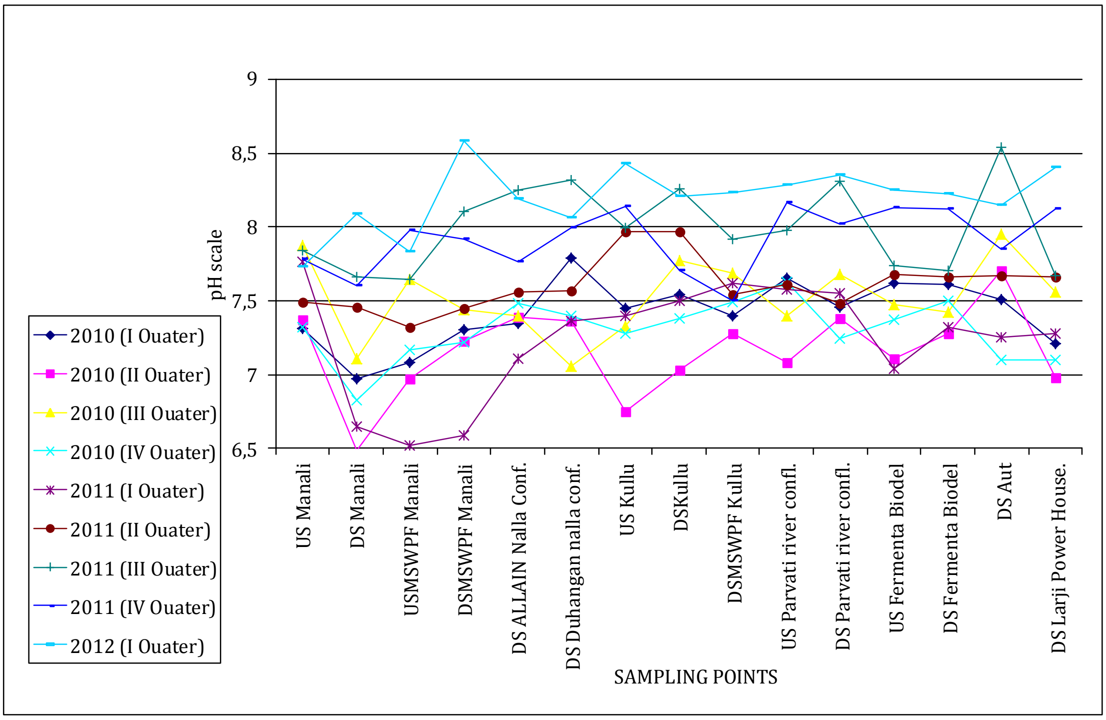
pH

The analysis of the pH graph shows that pH values remain in between 6.5 to 8.5 in all the quarters of the study period which is in an acceptable zone according to surface water quality standards. It has also come into the picture that the pH value has decreased in DS Manali as compared to US Manali on consistent basis in almost every studied quarter due to the pollution load of Manali city. Downstream of Kullu has also shown similar results, which is indicative of the fact that the river stretch between these municipalities receives organic pollutants in the form of leachates from solid waste dumps and the untreated sewage.

Dissolved Oxygen

After analysing the DO graph, the results show that the DO level ranges from 7 to 11 mg/l throughout the river stretch under study. The DO level in Beas River is quite high due to its turbulent nature. The graph shows that there is drastic depletion in the DO level at DS Manali as compared to US Manali which indicates the contribution in pollution due to Manali town. It is also noticed that the DO level increases towards reaching DS Larji power house in most of the quarters as the river gets stabilised after reaching Kullu. This justifies the river self-purification process and the Biochemical Oxygen Demand (BOD) stabilization.

Figure 3 pH Variation during study period



BOD

Biochemical Oxygen Demand (BOD), which is equivalent to the amount of oxygen required by aerobic micro-organisms to decompose the organic matter in a sample of water, such as that polluted by sewage. It is used as a measure of the degree of water pollution. The level of BOD has been found to be at an increased level downstream in each municipality. The BOD graph shows that the BOD level ranges from 0.1 to 0.7 mg/l in almost all the locations of study area except in DS Manali where it reaches to 11.0 & 2.8 mg/l in first & third quarter of the year 2010 respectively. It is worth mentioning that most of the hotels are located along the river bank and they discharge their partially treated or untreated sewage directly into the river. The leachates that originate as a result of solid waste dumps from the vegetable and fruit markets, sludge from the drains, and emptying of faecal sludge by tractors at *potato ground* and *kalath* directly or indirectly enter into the river. It fortifies the level of BOD and depletion of DO at downstream point of Manali. The various drains that join river Beas in Manali carry grey water from nearby villages along with cattle faeces and urine. All of them result into increase of the Biochemical Oxygen Demand of the river.

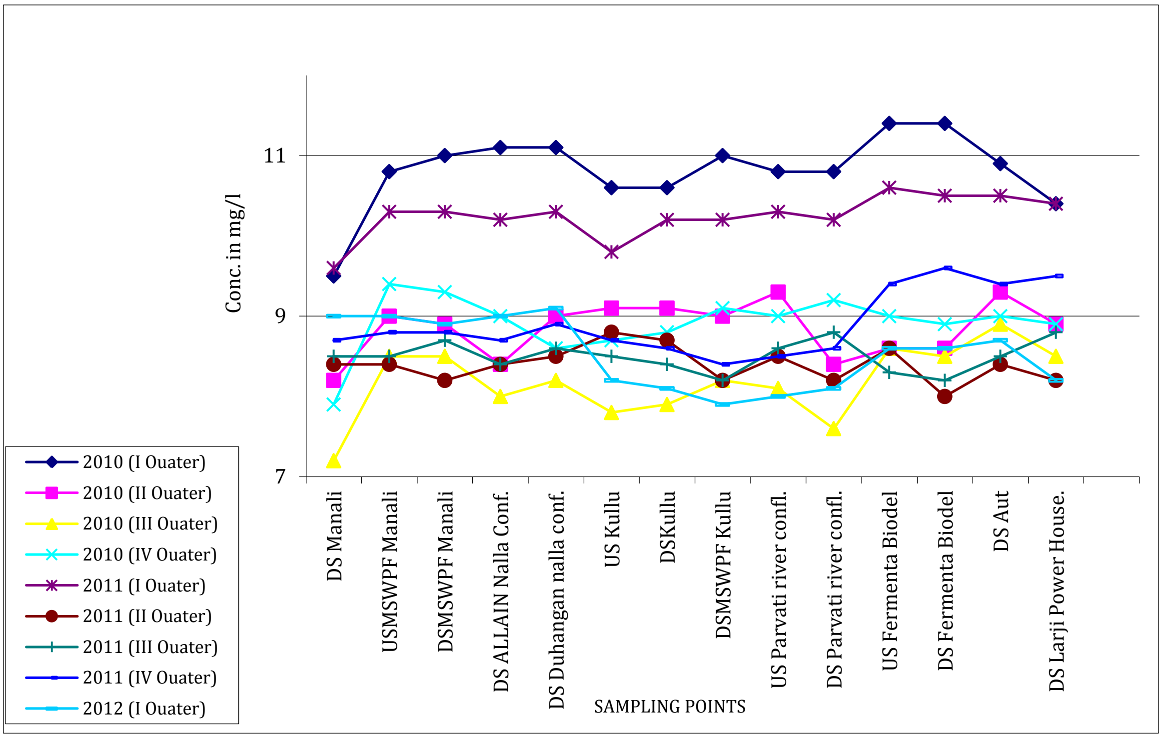


Figure 4 DO Variation during study period

Temperature

The temperature graph shows that the temperature ranges from 2.5 to 19 degree Celsius which shows only seasonal variations. However, temperature of river water has been found to be comparatively high at all downstream points of sampling.

Total Suspended Solids

The TSS graph shows that the TSS values are high in the third quarter of both the years which is only due to the pre-monsoon period. In the rest of the quarters the TSS values are quite stable. It has also been observed that in the year 2010 the TSS value of DS Manali is higher as compared to US Manali which is only due to the pollution load of Manali city as indicated from above parameters. TSS values are higher on account of increased construction along the river banks in one form or the other. The hydropower companies also flush their silt from time to time.

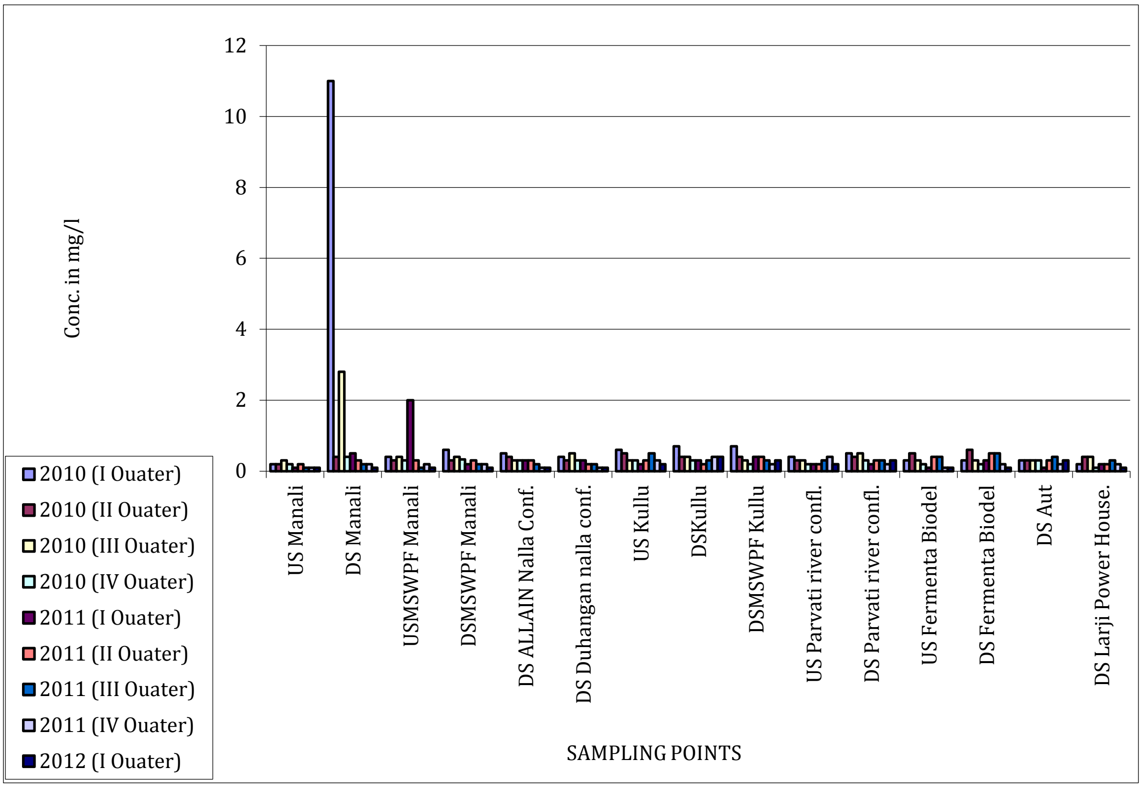


Figure 5 BOD Variation during study period (More clear illustration in appendix)

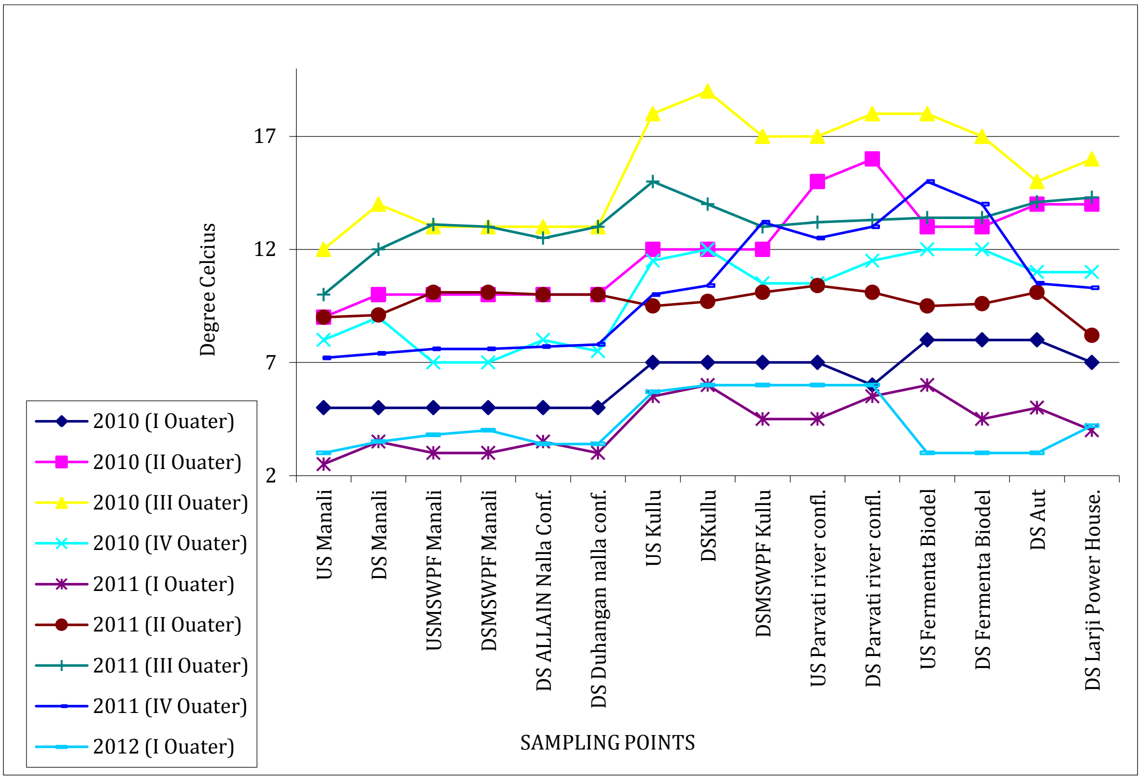


Figure 6 Temperature Variation during study period

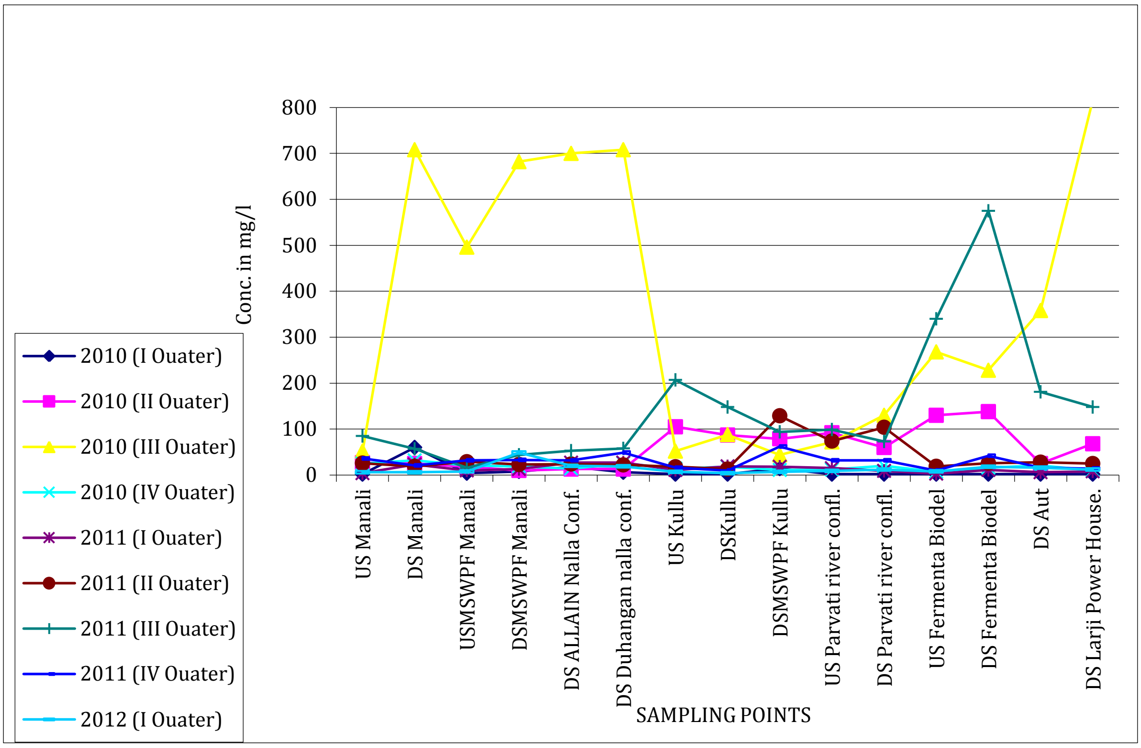


Figure 7 TSS Variation during study period (More clear illustration in appendix)

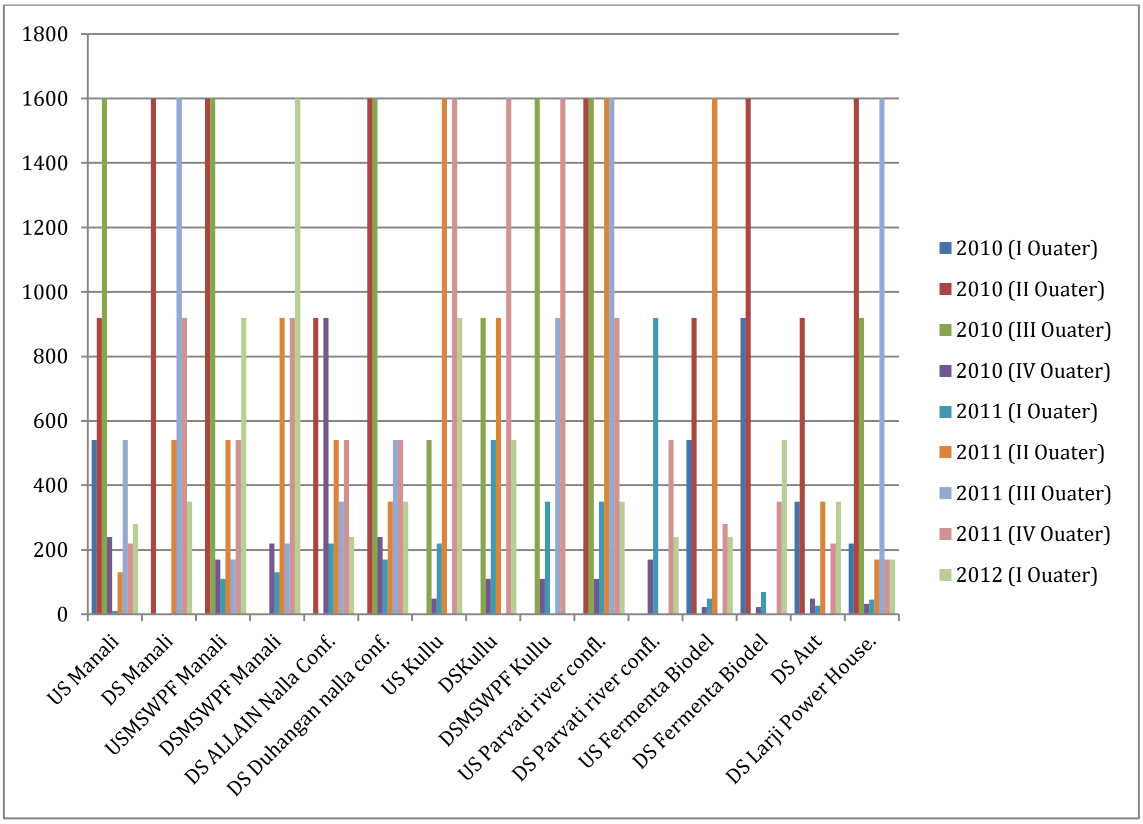


Figure 8 Total Coliforms (MPN/100ml)

Total Coliform & Faecal Coliform

During the study period, bacteriological sampling was also carried out at every point as pollution in DS cannot be ruled out due to various anthropogenic activities, and it is supported from the study that Coliform level (TC & FC) were found at increased levels at all DS points of the study area (Figure 8). The Total Coliform level (Most Probable Number/100 ml) is more than 500 in contrast to the standard of less than 500 set by central Pollution Control Board in India for outdoor bathing or recreational activities (Figure 9). The TC level should not exceed a number of 50 for drinking water as per the same standard, but on contrary the Total Coliform level at the sampling points have been found to be more than the standard required for drinking water.

Designated Best Use	Quality Class	Primary Water Quality Criteria
Drinking water source without conventional treatment but with chlorination	A	➢ Total Coliform organisms (MPN*/100 ml) shall be 50 or less ➢ pH between 6.5 and 8.5 ➢ dissolved oxygen 6 mg/l or more, and ➢ Biochemical Oxygen Demand 2 mg/ l or less
Outdoor bathing (organized)	B	➢ Total Coliform organisms(MPN/100 ml) shall be 500 or less ➢ PH between 6.5 and 8.5 ➢ Dissolved Oxygen 5 mg/l or more, and ➢ Biochemical Oxygen Demand 3 mg/l or less
Drinking water source with conventional treatment	C	➢ Total Coliform organisms (MPN*/100 ml) shall be 5000 or less ➢ pH between 6.0 and 9.0 ➢ dissolved oxygen 4 mg/l or more, and ➢ Biochemical Oxygen Demand 2 mg/ l or less
Propagation of wildlife and fisheries	D	➢ pH between 6.5 and 8.5 ➢ dissolved oxygen 4 mg/l or more, and ➢ Free Ammonia (as N) 1.2 mg/l or less
Irrigation industrial cooling and controlled disposal	E	➢ pH between 6.0 and 8.5 ➢ Electrical Conductivity less than 2250 micro mhos/cm ➢ Sodium Absorption Ration less than 26, and Boron less than 2 mg/l
*MPN: Most probable number (source CPCB 1978)		

Figure 9 Designated Best Use Classification of Surface Water (Source: Central Pollution Control Board)

Conclusion and Recommendations

The study shows that the Total Coliform and Faecal Coliform level during the studied months is considerably on the higher side which is indicative of the notion that the river receives untreated or partially treated sewage. The above facts justify the impression that water of River Beas is not fit for drinking and even for bathing in the study area. The presence of increased level of pollution in the river downstream Manali City in some seasons is primarily because of the increased tourist activities.

The change in water quality is due to non- implementation of urban sanitary laws and regulations e.g., 100 % coverage to the sewerage, control over open defecation, improvement and regular functioning of MSWPFs at Manali and Kullu. The deteriorating quality of water may impact the livelihood of people who depend on the income that they gain from the water adventure business like river rafting, river crossing and recreation for the tourists.

However, the State Pollution Control Board has issued orders to some hotels in Kullu-Manali that water and electricity supply will be cut leading to a closure on causing pollution in Beas River. Following the directions of National Green Tribunal (NGT) to close down 34 hotels that are operating along Beas River in Kullu-Manali area without obtaining required permissions and causing pollution in the river, the board has directed electricity, irrigation and public health departments to snap water and electricity supply to these hotels. In its earlier order, the tribunal had made it clear that whosoever is found throwing or dumping any such material or effluents directly or indirectly into river Beas or its tributaries or even at its banks, will have to pay a sum of USD 1500 as compensation on the basis of "polluter pays" principle. It had accordingly directed the authorities to notify these directions for knowledge and compliance by public at large. This seems to be a good sign for the future of Beas River in general and the livelihood of people in particular who depend on the quality of water e.g., fishermen, horticulturists, agriculturists and adventure operators.

Acknowledgements

The authors thank PCB laboratory Sunder Nagar for all assistance and Sh. Kamal Kant, Senior Lab Assistant, PCB for his timely contribution during the study period. Thanks are also due to our families who consistently encouraged us to complete the study. We are thankful to the anonymous reviewers too for reading each line of the paper meticulously and providing valuable suggestions in order to improve the quality of the present work.

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Appendix

Sampling Locations	Colour	DO (mg/l)	Odour	pH	Temp. (^{0}C)	BOD (mg/l)	TSS (mg/l)	TC (MPN/ 100ml)	FC (MPN/ 100ml)
US Manali	Clear	10,6	Odour free	7,31	5,0	0,2	2,0	540	27
DS Manali	Light grey	9,5	Odour free	6,97	5,0	11,0	60,0	>2400	>2400
USMSWPF Manali	Clear	10,8	Odour free	7,08	5,0	0,4	4,0	>2400	540
DSMSWPF Manali	Clear	11,0	Odour free	7,30	5,0	0,6	8,0	>2400	920
DS Allain Nalla conf.	Clear	11,1	Odour free	7,35	5,0	0,5	18,0	>2400	240
DS Duhangan nalla conf.	Clear	11,1	Odour free	7,79	5,0	0,4	6,0	>2400	350
US Kullu	Clear	10,6	Odour free	7,45	7,0	0,6	2,0	>2400	350
DSKullu	Clear	10,6	Odour free	7,54	7,0	0,7	2,0	>2400	920
DSMSWPF Kullu	Clear	11,0	Odour free	7,40	7,0	0,7	14,0	>2400	1600
US Parvati river confl.	Clear	10,8	Odour free	7,65	7,0	0,4	2,0	>2400	240
DS Parvati river confl.	Clear	10,8	Odour free	7,46	6,0	0,5	2,0	>2400	920
US Fermenta Biodel	Clear	11,4	Odour free	7,62	8,0	0,3	2,0	540	14
DS Fermenta Biodel	Clear	11,4	Odour free	7,61	8,0	0,3	2,0	920	27
DS Aut	Clear	10,9	Odour free	7,51	8,0	0,3	2,0	350	17
DS Larji Power House.	Clear	10,4	Odour free	7,21	7,0	0,2	2,0	220	8

Table 1 Analysis results of Beas River - collected in the month of January- 2010

ng Locations	Colour	DO (mg/l)	Odour	pH	Temp. (^{0}C)	BOD (mg/l)	TSS (mg/l)	TC (MPN/ 100ml)	FC (MPN/ 100ml)
US Manali	Colourless	8,9	Odour free	7,37	9,0	0,2	27,0	920	79
DS Manali	Colourless	8,2	Odour free	6,49	10,0	0,4	25,0	1600	130
USMSWPF Manali	Colourless	9,0	Odour free	6,97	10,0	0,3	18,0	1600	170
DSMSWPF Manali	Colourless	8,9	Odour free	7,23	10,0	0,3	10,0	>2400	280
DS Allain Nalla Conf.	Colourless	8,4	Odour free	7,39	10,0	0,4	13,0	920	33
DS Duhangan nalla conf.	Colourless	9,0	Odour free	7,36	10,0	0,3	13,0	1600	79
US Kullu	Light Brown	9,1	Odour free	6,75	12,0	0,5	105,0	>2400	350
DSKullu	Light Brown	9,1	Odour free	7,03	12,0	0,4	87,0	>2400	540
DSMSWPF Kullu	Light Brown	9,0	Odour free	7,28	12,0	0,4	79,0	>2400	540
US Parvati river confl.	Light Brown	9,3	Odour free	7,08	15,0	0,3	92,0	1600	94
DS Parvati river confl.	Light Brown	8,4	Odour free	7,38	16,0	0,4	60,0	>2400	110
US Fermenta Biodel	Light Brown	8,6	Odour free	7,11	13,0	0,5	130,0	920	240
DS Fermenta Biodel	Light Brown	8,6	Odour free	7,28	13,0	0,6	138,0	1600	540
DS Aut	Light Brown	9,3	Odour free	7,70	14,0	0,3	25,0	920	130
DS Larji Power House.	Light Brown	8,9	Odour free	6,98	14,0	0,4	68,0	1600	220

Table 2 Analysis results of Beas River- collected in the month of April- 2010

Sampling Locations	Colour	DO (mg/l)	Odour	pH	Temp. (^0C)	BOD (mg/l)	TSS (mg/l)	TC (MPN/ 100ml)	FC (MPN/ 100ml)
US Manali	Grey	8,2	Odour free	7,87	12,0	0,3	52,0	1600	70
DS Manali	Grey	7,2	Odour free	7,11	14,0	2,8	708,0	>2400	920
USMSWPF Manali	Grey	8,5	Odour free	7,64	13,0	0,4	496,0	1600	350
DSMSWPF Manali	Grey	8,5	Odour free	7,44	13,0	0,4	682,0	>2400	540
DS Allain Nalla Conf.	Grey	8,0	Odour free	7,40	13,0	0,3	700,0	>2400	350
DS Duhangan nalla conf.	Grey	8,2	Odour free	7,06	13,0	0,5	708,0	1600	140
US Kullu	Clear	7,8	Odour free	7,33	18,0	0,3	52,0	540	79
DSKullu	Clear	7,9	Odour free	7,77	19,0	0,4	88,0	920	110
DSMSWPF Kullu	Grey	8,2	Odour free	7,69	17,0	0,3	44,0	1600	350
US Parvati river confl.	Grey	8,1	Odour free	7,40	17,0	0,3	72,0	1600	110
DS Parvati river confl.	Grey	7,6	Odour free	7,68	18,0	0,5	130,0	>2400	240
US Fermenta Biodel	Brown	8,6	Odour free	7,47	18,0	0,3	268,0	>2400	170
DS Fermenta Biodel	Brown	8,5	Odour free	7,42	17,0	0,3	228,0	>2400	220
DS Aut	Brown	8,9	Odour free	7,95	15,0	0,3	358,0	>2400	350
DS Larji Power House.	Grey	8,5	Odour free	7,56	16,0	0,4	816,0	920	70

Table 3 Analysis results of Beas River- collected in the month of July- 2010

Sampling Locations	Colour	DO (mg/l)	Odour	pH	Temp. (^0C)	BOD (mg/l)	TSS (mg/l)	TC (MPN/ 100ml)	FC (MPN/ 100ml)
US Manali	Clear	8,6	Odour free	7,32	8,0	0,2	25,0	240	49
DS Manali	Clear	7,9	Odour free	6,83	9,0	0,4	32,0	>2400	920
USMSWPF Manali	Clear	9,4	Odour free	7,17	7,0	0,3	21,0	170	22
DSMSWPF Manali	Clear	9,3	Odour free	7,22	7,0	0,3	19,0	220	26
DS Allain Nalla Conf.	Clear	9,0	Odour free	7,48	8,0	0,3	14,0	920	110
DS Duhangan nalla conf.	Clear	8,6	Odour free	7,40	7,5	0,3	26,0	240	49
US Kullu	Clear	8,7	Odour free	7,28	11,5	0,3	14,0	49	8
DSKullu	Clear	8,8	Odour free	7,38	12,0	0,3	18,0	110	27
DSMSWPF Kullu	Clear	9,1	Odour free	7,49	10,5	0,2	11,0	110	33
US Parvati river confl.	Clear	9,0	Odour free	7,63	10,5	0,2	12,0	110	23
DS Parvati river confl.	Clear	9,2	Odour free	7,24	11,5	0,3	20,0	170	33
US Fermenta Biodel	Clear	9,0	Odour free	7,37	12,0	0,2	7,0	23	5
DS Fermenta Biodel	Clear	8,9	Odour free	7,50	12,0	0,2	16,0	23	5
DS Aut	Clear	9,0	Odour free	7,10	11,0	0,3	21,0	49	11
DS Larji Power House.	Clear	8,9	Odour free	7,10	11,0	0,1	10,0	33	5

Table 4 Analysis results of Beas River- collected in the month of October- 2010

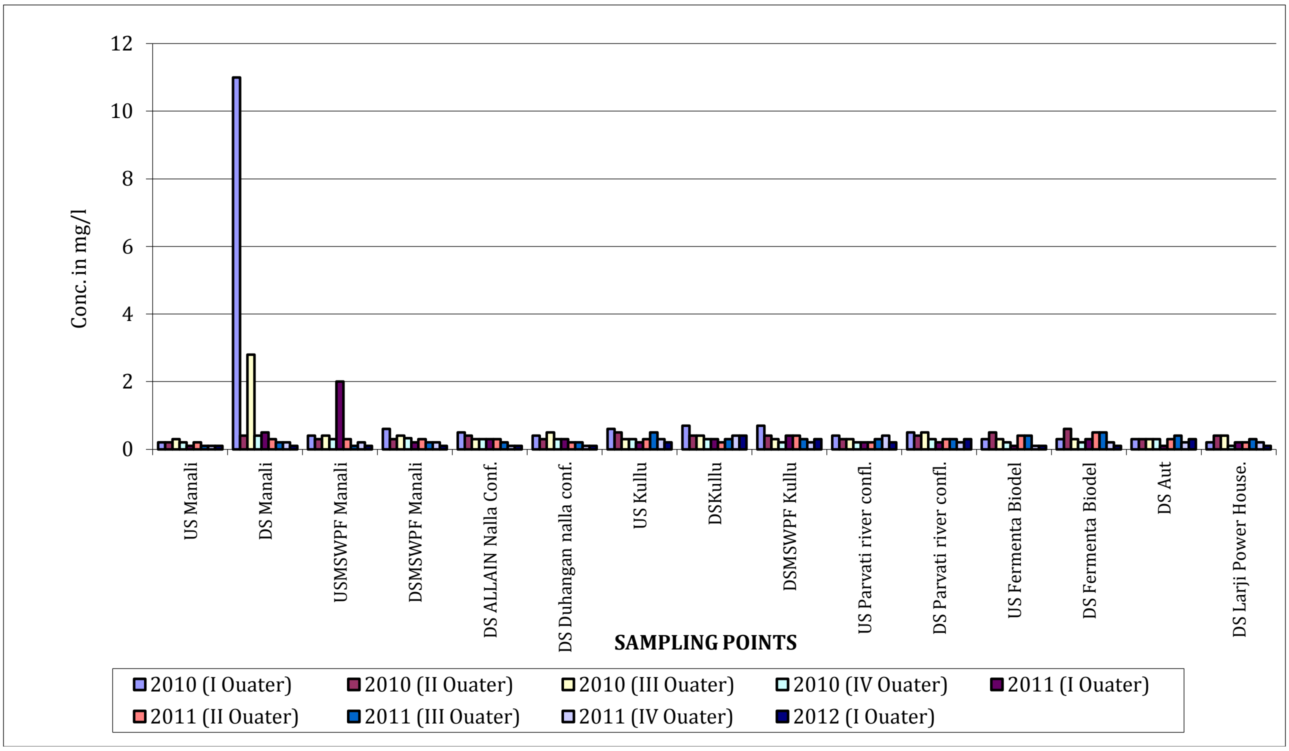

Figure 5 BOD Variation during study period

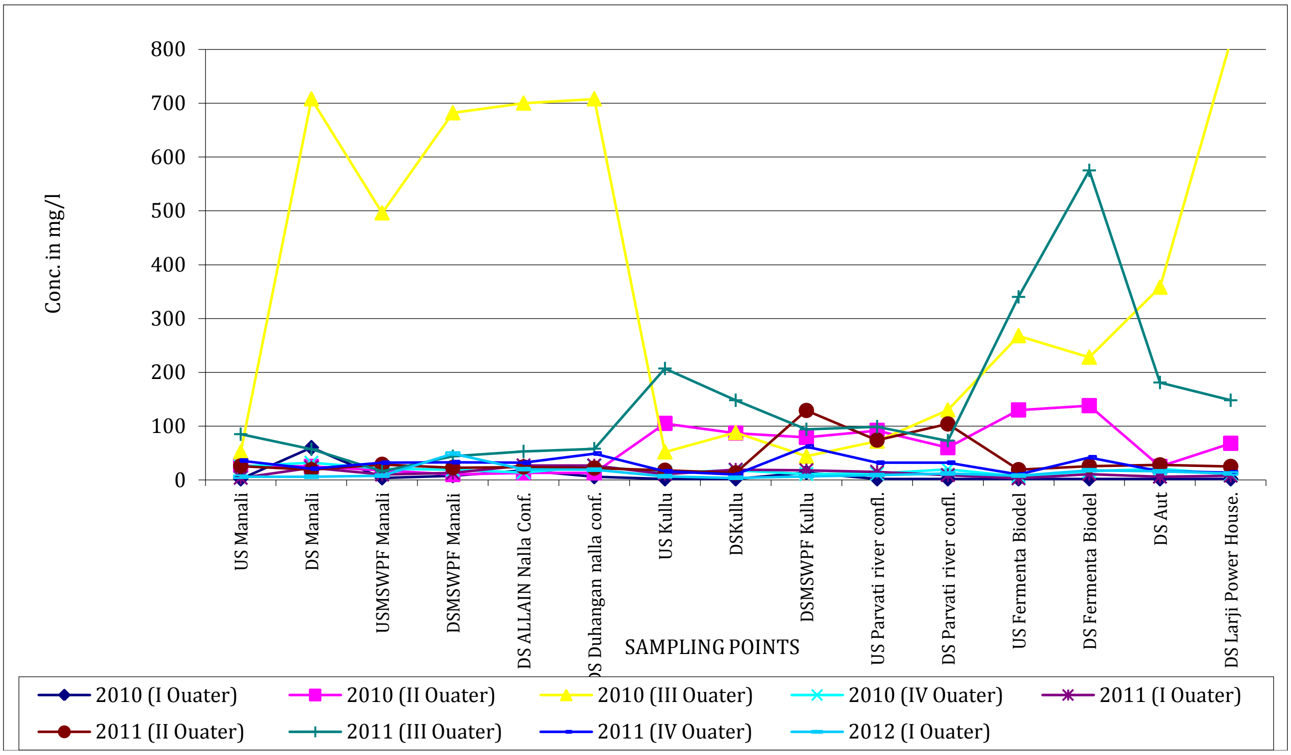

Figure 7 TSS Variation during study period

Survey of Agricultural Practices and Alternatives to Pesticide Use to Conserve Water Resources in the Mojanda Watershed, Ecuador

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Abstract

Agriculture in the Mojanda Watershed is facing rainfall reductions caused by climate change. Reductions of water availability in the Watershed are also due to constant extension of the agricultural activities into the páramo ecosystem above 3000m a.s.l., with this ecosystem having immanently important functions in the local water balance. The application of pesticides threatens the quality of water and with less precipitation contaminations will further concentrate in the outflow. To analyse problems associated with agricultural practices in the area a questionnaire about agricultural practices (28) was conducted and fields (20) were surveyed for pests and diseases with a focus on potatoes (*Solanum tuberosum L.*), tree tomatoes (*Solanum betaceum Cav.*) and peas (*Pisum sativum L.*). Potatoes were infected to a low degree with *Phytophthora infestans* and according to the farmers the Andean potato weevil (*Premnotrypes* spec.) caused the biggest losses. To combat the weevil the soils are disinfected with toxic Carbofuran (WHO Class 1B). Tree tomatoes showed symptoms of various fungal diseases. Most important was *Fusarium solani* causing the branches to rot and Anthracnosis (*Colletotrichum gloeosporioides*) causing the fruits to rot. Fungicide applications were correspondingly high. Peas were only minorly affected by Ascochyta blight (*Mycosphaerella pinodes*) and a root rot. Overall 19 active ingredients were applied of which fungicide Mancozeb (WHO class table 5) and insecticide Carbofuran (WHO Class 1B) were applied the most. Approved Integrated Pest Management methods are advised to reduce pesticide use. For tree tomatoes regular cutting of branches infected with *F. solani* and regular collection and disposal of infected fruits with Anthracnosis are advised. For potatoes plastic barriers around the fields prevent the Andean potato weevil from laying eggs thus reducing infestation with the larvae in the tubers. Local bioinsecticide "Biol" seems effective and without harm to the environment, although not used by many farmers. Organic fertilization promises to restore decreasing soil fertility, water holding capacity and reduce erosion. The here presented alternatives and strategies to reduce pesticide use pose an opportunity to preserve the water resources of the region.

Keywords: *Integrated Pest Management (IPM); tree tomato; potato; watershed; pesticide use; Ecuador*

Introduction

Over half of the world's rural poor are smallholder farmers. However they produce a remarkable 80% of food supplies in developing countries. Yet about 75% of those worst affected by malnutrition live in rural areas of developing countries despite their strong connections to food production

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(Colette *et al*., 2011). In the Mojanda Watershed in the Province of Imbabura, Ecuador, smallholders dominate agricultural production. They have small land sizes and depend on agriculture for their food production. As indigenous groups (Kichwa and Cayambe) they are segregated from the regular Spanish-dominated Ecuadorian culture and society. They have their own traditions and own belief systems. These factors contribute to them having bad connections to markets and little financial means to purchase new technologies or to obtain an education about agricultural practices.

Environmental problems in the Mojanda Watershed have increased over recent years. One of the primary topics of concern in the area is that of water quality and quantity, which are affected by agricultural and household activities, such as sewage disposal and agricultural run-off, leading to a contamination of ground water and water bodies. The intensive agricultural use in the area of the Mojanda Watershed as well as insufficient treatment of sewage water, has led to a rapid eutrophication with high phosphorus levels throughout the year in Lake San Pablo or Imbakucha below (Gunkel, 2002: 42). In recent years it has become widely accepted that climate change will also have negative effects on the water supply in the near future, causing little or no rainfall in some years, and excessive rainfall and/or floods in other years. These effects are foreseen to be additionally strengthened by El Niño and La Niña[1] in some parts of the world, including the study area (Paeth *et al*., 2008: 284). The pressure on water quality is increasing and with a lower input of water in the catchment areas, the residues from agriculture are increasingly concentrated in the outflow to the lake. Pesticides in drinking water are known to be a serious threat to human health and agricultural practices have a huge influence on the above mentioned problems. It is necessary to analyse them in order to find more sustainable alternatives. The definition of sustainability in this study will follow the Council of Sustainable Agriculture and Rural Development of the Food and Agriculture Organisation of the United Nations (FAO). “(...) such sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable” (FAO, 1989).

The problems of the area are argued to be environmental but the solution is to be found within the population and its farmers. A cultivation which considers and works with natural processes is found to need less pesticides and additional fertilizers. Many studies focus specifically on one aspect of farming, such as productivity and technology use. In contrast, nutrient dynamics in the soil, effects on biodiversity or the efficiency of extension services

[1] El Niño and La Niña describe a periodic weather phenomenon of the southern Pacific Ocean resulting from temperature variation in surface water in the eastern tropical Pacific Ocean and from variation of the air surface pressure in the western tropical Pacific.

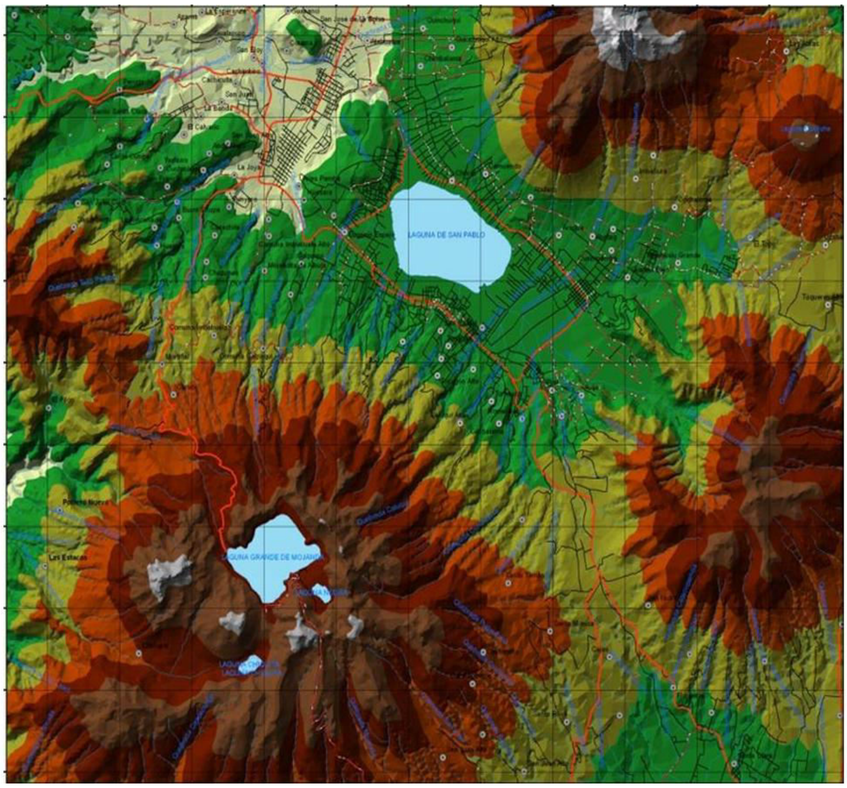

Figure 1 Study region between Lago San Pablo and Laguna de Mojanda (O. Rosales, Universidad Tecnica del Norte)

through agriculture need to consider all agricultural practices and see the farm as an entire system. Some scholars conducted research about agricultural practices in the whole region (Pandey *et al*., 2001, Barrow *et al*., 2008 or Majumder *et al*., 2010). This study will give an overview of agricultural practices within the Mojanda Watershed and will relate them to agroecosystem processes. With a focus on Integrated Pest Management (IPM) and plant diseases, the main issues for achieving sustainability will be discussed. Additionally, this study is the first in-depth study on agricultural practices in the Mojanda Watershed, and the first to uniquely link the problems of the area with sustainability. The following questions are focused on and shall be answered by this study:

(1) What are the main agricultural practices in the study region regarding crops grown, the use of pesticides, cropping patterns?

(2) With a focus on potato (*Solanum tuberosum* L.), tree tomato (*Solanum betaceum* Cav.) or pea (*Pisum sativum* L.), what are the present pests and diseases and how are they presently controlled If used, which pesticides and fertilizers are applied?

(3) Which IPM methods are currently in use and what are the potential IPM methods which could be used to protect water resources of the watershed?

Case study

Data collection

A questionnaire was applied to gain insight on the agricultural production methods in the area. Together with a quantification of pests and diseases of the grown crops and further field investigations, possibilities, which will reduce agricultural pollution, have been sought out.

The data collection process took place in June 2011 and consisted of three stages. First the three crops to be focused on were identified: Potatoes were chosen as a traditional, yet input intensive crop; peas as a leguminous crop and tree tomato as an example for a cash crop. Next, a structured questionnaire (n= 28) was designed to find out about land use and agricultural practices and participants were chosen based on whether or not they farmed potatoes, tree tomatoes or peas. Snowball sampling was used at times to get in touch with other farmers in the study area who farmed these crops. Land sizes of the farms and indigenous heritage are homogeneous in the watershed (Wales, 2012) and found agricultural practices within the sample farmers may be seen representable for the watershed. Information was collected regarding crop rotations, fertilizer use, pesticide and insecticide use and local methods (non-pesticide) to mitigate pest and disease damage. In the third part an assessment of the three crops for damage by pests and diseases was realized. In total 20 fields of the participants of the questionnaire were selected. In three levels of different altitudes two fields of each of the crops were chosen to get an idea about the pest and disease distribution and their general condition. Additionally in potatoes four fields with pesticide application and four fields without pesticide application were selected. The damage on the crops was measured with the estimated severity. Severity was measured by recording the amount of infected or eaten parts of the plants. Diseased plants were assessed for the type of symptoms in order to know if the disease is systemic or local on certain plant organs, including the roots. Diseases were identified according to relevant literature. This assessment was only conducted when it was appropriate which means only when there was an apparent phytosanitary problem. To exclude border effects the counting was always done inside the field. Comparisons between inside and on the borders of the field were done to confirm findings.

Analysis

All collected information was analysed to understand environmental, agricultural and local practices in the Mojanda Watershed. The structured questionnaire on the other hand was interpreted using qualitative analysis (see for e.g. Atteslander *et al*., 2008) and if possible using descriptive statistics. A content analysis of literature was conducted to formulate solutions to the problems identified. Prevailing diseases were analysed for their risk potential concerning yield losses based upon previous scientific reports. Furthermore, it was tried to identify causes of disease outbreaks. Potential IPM measures and alternatives to current pesticide use are proposed using scientific literature and evaluated concerning their practicability for the study region.

Study area

The Mojanda Watershed is located the mountainous slopes above lake San Pablo and 12,440 ha in size (Figure 1). The precipitation varies around Lake San Pablo between 800-1250mm annually with a dry season between June and September and a humid season from October to May (CEPCU, 2001). Cropping area and therefore study area extends from the lake into the tropical montane forest of the *páramo* (2660 to 3100 m a.s.l.) (Moreno *et al*., 2007). The *páramo* has a very important hydrological function. The plants which grow there have special physiological features which catch water from the mist of the higher altitudes. The *páramo* collects water and provides the lower areas even in the dry season with water through streams (Buytaert *et al*., 2007: 23). There is an ongoing trend to shift potato cultivation into the *páramo* thus extending the agricultural border, which poses a threat to the water supply function of this ecosystem.

After the Spanish conquest the land had been, with one exception, under the rule of three haciendas in the whole region around Lake San Pablo. In the 1960s an Agrarian Reform took place under the direction of the Ecuadorian government and the land of the haciendas was distributed among the indigenous population (Mora in Chiu, 2008: 53). The indigenous population was already pushed onto marginal land in the mountains and through the reform the situation became institutionalized. In a study carried out by M. E Wales (2012) it was found that nowadays land size per household in the Mojanda Watershed is on average 0.8 h with an average household size of 5.7 persons. The study is based on data collected in three rural Parishes of the Mojanda Watershed, Eugenio Espejo, González Suárez and San Rafael, and can be viewed as reflective of the entire Watershed. 38.6% of the population considered themselves illiterate, while 38.6% reported basic literacy levels. This means that 77.2% of the population can either read or write at only a very basic level or not at all (Wales, 2012). The income which is derived from agricultural activities is with only 16% at first surprisingly low. But almost all of the respondents reported some sort of off-farm employment activities. Agriculture maintains food security and allows them to be independent from the market which guarantees them affordable food. Moreover, an interesting finding of the study by Wales (2012) was that 75.9% of farmers reported a decrease in harvest over the past five years. Furthermore, 35.2% of the sample mentioned a change in climate, such as different rain patterns and less rain. In some communities at the low and intermediate altitude the cultivation of tree-tomatoes as a cash crop has been introduced. Farmers reported to have started to cultivate tree tomatoes in the year of 2008.

Findings

Agricultural practices

The crop diversity that farmers planted was relatively high. Farmers were asked which crops are used in their crop rotation. Traditional crops as well as new crops were part of their rotations. Maize was planted the most with 23 out of 28 farmers. Fava beans (22), potatoes (20) and beans (20) followed. 17 farmers had a tree tomato plantation. Only three farmers within the sample cultivated strawberries. The main crop is maize but often intercropped with beans. Intercropping is very common in the region. Maize is not only planted with beans but also with sambo, a squash species, or fava beans. Other combinations include potato with peas, peas with fava beans, fava beans with potatoes and quinoa with potato. The use of crop rotation was common and only four out of 28 farmers did not rotate their crops. Often tree tomato farmers did not rotate their crops, because the fields have to be close to the house to facilitate harvest and tree tomato farmers often only owned one plot close to the house. Most farmers (21) included a nitrogen-fixing Fabaceae in their crop rotation. On average the fields were left as a fallow for 1.5 months. Fertilizers were applied in different ways. Ten farmers used only manure and likewise ten farmers used only mineral fertilizers. Mostly mineral fertilizers were applied for potatoes. In the case of tree tomatoes mainly manure was used and pea farmers tended to fertilize with manure and a minor percentage with mineral fertilizers or not at all. Overall potatoes and tree tomatoes received more mineral fertilizers and more fertilization in general than peas (see table 1). Peas are mostly produced for auto consumption and in most cases are not sold on the market. Manure is collected and then brought to the field or the animals are kept on the field, either in the fallow period of one month or in case of the tree tomatoes between the stems. The amounts of fertilizers were only noted as high, medium or low because questioned farmers could only tell rough estimates.

Nine of the sample farmers did not use pesticides. 15 of the 19 farmers who applied pesticides did so in a regular pattern such as once a week or once a month. Only 14 farmers though could answer the questions of which products they applied. Differences in the amounts applied are unaccounted. It was found that ten farmers sprayed insecticides and eleven fungicides, seven used both at the same time and nine did not use any pesticides as mentioned above. 19 different active ingredients were found to be in use by the sample in the Mojanda Watershed. On average they used products with three different active ingredients, of which Mancozeb (8) was the most used, followed by Carbofuran (5), Cymoxanil (5) and Metalaxyl (4). Mancozeb, Cymoxanil and Metalaxyl are all fungicides while Carbofuran is an insecticide used to disinfect soils and mostly used for potatoes (27% of all applied pesticides for potato) against the Andean potato weevil and for peas. The most used pesticides for tree tomatoes were fungicides, which reflects the phytosanitary problems with fungi (see table 1). According to WHO classification (Tomlin, 1994), Mancozeb belongs to table 5 (unlikely to present an acute hazard) Carbofuran to Ib (highly hazardous) Cymoxanil to III (slightly hazardous) and Metalaxyl to III. Only rarely used was Chlorpyrifos (3), Benomyl (3), Cypermethrin (1) and Methamidophos (1). However, they belong to higher toxicity classes: II (moderately hazardous), Table 5, II, and IB. Benomyl is banned in Europe. Eight farmers reported that they received some kind of extension service, for example from the CEPCU

	Diseases	Most applied Pesticides (ai)	Fertilizers
Potato	1. Late blight (*Phytophthora infestans*), 2. Andean potato weevil (*Premnotrypes spp.*) 3. Bacterial blight (*Ralstonia solanacearum*) Potato tuber moth complex	Carbofuran (27%) Mancozeb (18%) Chlorpyrifos (18%) Cymoxanil (18%) Metalaxyl (18%)	Mineral fertilizer 53% Manure 23%
Tree Tomato	1. Palo seco (*Fusarium solani*) 2. Lancha (*Phytophthora infestans*) 3. Anthracnosis (*Colletotrichum gloeosporioides*)	Mancozeb (25%) Benomyl (15%) Carbendazim (10%) Cymoxanil (10%)	Manure 50% Mixed 37,5%
Pea	1. Ascochyta blight (*Mycosphaerella pinodes* 2. Fusarium wilt (*Fusarium oxysporum*)	Mancozeb (20%) Carbofuran (20%) Cymoxanil (20%) Acarex (20%) Propineb (20%)	Manure 42,9% Mineral fertilizer 28,6% None 28,6%

Table 1 The studied crops (potato, tree tomato, and pea), its diseases, its most applied pesticides and its most used fertilizers. No of answers about active ingredients (ai) used/No of respondents: potato 11/6, tree tomato 20/6, pea 5/2; respondents about fertilizer: potato 13, tree tomato 8, and peas 7

(a local NGO), training in pesticide handling, training on vegetable growing, pesticide storage training or in the form of extra payment when buying strawberries receive extension services. No public extension service has ever reached the farmers.

Prevalence of pests and diseases and control methods

Potatoes

Three (two under pesticide application, one without) out of eight potato fields showed no symptoms of late blight (*Phytophthora infestans* (Mont.) De Bary). The rest showed symptoms, but percentages of affected leaf area was overall less than 10%. Twelve out of thirteen farmers which cultivated potatoes considered late blight a problem, but the grade of perceived loss due to the disease varied from low to high. The rate of incidence of *P. infestans* was overall low and economic losses are assumed to be marginal especially because potatoes were just about to be harvested. Yet Late Blight is the pathogen which affects potato production the most in Ecuador and most other parts of the world. Its physiological optimum is in cold and moist climates. In areas of continuous potato production like the study region the spores are continuously present in the soil and a reinfection is a permanent threat. However *P. infestans* cannot be controlled completely by rotation, because the spores are transported by the wind and travel long distances (Pumisacho & Sherwood, 2002). First measure of control is to use resistant varieties. A lot of potato varieties only bear a vertical resistance, which can change quickly and make the variety susceptible again (Pumisacho & Sherwood, 2002). Disease forecasting which reports genotypes helps to identify the right cultivars to combat the disease. The method of spraying the plants with a filtered solution of wood ash in water is one local strategy however without verification.

Nine farmers considered the Andean potato weevil (*Premnotrypes spp*.) a problem and they perceived it more dangerous than late blight. No weevil was found on the field and neither feeding marks on the leaves found, but the larvae were found in storage spaces for potatoes, which proves the existence of the weevil in the area. The Andean potato Weevil poses a big threat to Ecuadorian potato production. If the crop is not managed properly, crop losses can be as high as 80% (Muñoz & Cruz, 1984, cited in Crissman *et al*., 1998), in others the maximum is 30% (Fankhauser, 1999). Farmers attempt to control the Andean potato weevil mainly by using several applications of often highly toxic insecticides like Carbofuran to disinfect the soil. With spray application timing is crucial because the beetle is only susceptible during the time when they lay their eggs. However, with continuous potato cropping the weevils can still survive in the remaining tubers. Crop rotation is therefore absolutely necessary to reduce infestation (Crissman *et al*., 1998). Farmers in the research area reported collecting potato weevil larvae to reduce infestation. Looking at the life cycle and how the beetle reinfests the fields from other fields, this method cannot be successful. Plastic barriers can be a means to reduce the damage caused by the Andean potato weevil. In the study by Kuschel *et al*. (2009) the barriers were equally effective compared to a farmer's practice of applying insecticides four times in a fallow-potato rotation scheme. In a potato-potato rotation system the effect of the barriers together with one application of insecticides was superior to the farmer's practice. The cost for the new method of plastic barriers was equivalent to two or three pesticide applications per hectare. Plastic is available everywhere, it can be purchased in nearby cities and can contribute greatly to the reduction in insecticide applications.

In one field a few plants were infected with bacterial wilt (*Ralstonia solanacearum* Smith), but no farmer mentioned the disease and seems to be without history in the area. If the incidence of bacterial wilt is low, infected plants should be removed as quickly as possible to avoid a bigger outbreak. Also leftover tubers can maintain the inoculum and the plants should be removed in the next cycle. Using plant resistances would be the most effective way to control bacterial wilt besides avoiding solanaceous crops for a minimum of two years (Priou *et al*., 2011).

In storage for potatoes larvae and imago of the potato tuber moth complex were found and also farmers reported the problem. The larvae feed on the potatoes and the imago reinfest the potatoes. Potato tuber moth (PTM) is another reason for heavy insecticide applications. PTM granulovirus (PoGV) and *Bacillus thuringiensis* Berliner ssp. *kurstaki (*Btk) provide strong alternatives to manage field infestations of potato tuber moth prior to harvest, thus reducing the risk of tuber infestations in storage (Arthurs *et al*., 2008). The costs are low and the concentrates of *Bacillus thuringiensis* ssp. *kurstaki* (*Btk*) can be obtained in shops and then reformulated with talcum to protect the potatoes in stores (1,50$/200kg potato) (Arthurs *et al*., 2008: 1544). The International Potato Center (CIP) offers parasitoids against the tuber moth (*Copidosoma koehleri*, *Orgilus lepidus*, *Apanteles subandinus)* to national programs of integrated pest management. Used as inoculative biological control they can bring back species lost through intensive pesticide use. The combination of sexual pheromones and insecticides so called attract-and-kill method is another successful IPM measure and proved to reduce males of PTM, both in storage and field situations, by about 90% until 60 days after application (CIP internet resource, 2009).

Tree tomatoes

Tree tomatoes are cultivated between 1800 and 3200m a.s.l. in most of the higher provinces of Ecuador. In recent years the economic value has increased due to the higher demand for tree tomatoes. But because of their value and due to its many pathogens, tree tomatoes are also being sprayed intensively.

Six out of eight farmers considered *Phytophthora infestans*, commonly known as “Lancha”, to be a problem for their tree tomatoes but losses in terms of harvest and affected plants were generally perceived as low. Incidence of *Phytophthora infestans* in the field was correspondingly low and always stayed under the 10% level of affected leaf area or was not present at all. Five farmers named *Fusarium solani* link (“Palo Seco”) as a problem in their plantation but perceived their losses as intermediate (moderate). *Fusarium solani* occurred in all fields and incidence of affected branches was on average 2.1 branches, however with a high standard deviation. *Fusarium solani* is the disease agent of a rot of the trunk, known as “Palo Seco” or “Mancha Negra del Tronco”. The first symptoms appear in the first stages of development of the plants. Infections in the higher parts of the plants can travel downward easily and then infect the vulnerable stem (Revelo *et al.*, 2006). *Fusarium solani* originates in Ecuador in the province Tungurahua where in the 1990s it had its only distribution area. Now the disease has spread into all major cropping areas of tree tomato (INIAP, 2010). Symptoms of Anthracnosis (*Colletotrichum gloeosporioides* Penz), locally known as “Ojo de Pollo”, on the fruits were found in all fields, however the incidence was not able to be counted as farmers remove the infected fruits. All three farmers who estimated losses from the disease considered their loss as high. *Alternaria* spec*.* (”Lancha Amarilla”) was found in some fields but incidence was very low. Five farmers reported that aphids occupy the tips

of the branches and suck on the young leaves. Deformed leaves due to

Tomato spotted wilt virus (TSWV) were found in all fields and is probably connected with the presence of aphids. One farmer reported of symptoms that could be the result of an infection with the nematode *Meloidogyne* spec. The nematodes kills off the roots and reduces the normal lifetime of 4 years of the plants substantially. Especially *M. incognita* reduces the life and cropping time of the tree, reducing the total harvest to about 30%; entire plantations had to be given up due to the attack of the nematode (Revelo *et al*., 2006).

Tree tomatoes should not be planted where other crops of the solanaceous family have been grown in the previous three years. *P. infestans* and other pathogens of Solanaceae can survive in the soil and can infect the plantation. Most diseases though are already transferred from the nursery. Farmers need to especially pay attention to the roots and look for galls of *Meloidogyne incognita*. Seeds can also transfer diseases and certified disease-free mother plants guarantee healthy plants (Revelo *et al*., 2006: 60). Plants in the study area are grown very close to each other and disease can spread easily through the plantation. The farmers intertwine the branches to make the plants more resistant to wind. Revelo *et al*. (2006) recommends a distance of two meters between the plants. To reduce inoculum of fungal disease like *Fusarium solani* and Anthracnosis, infected branches, infested fruits and rotting fruits should be buried or burned (Revelo *et al*., 2006). Farmers in the study region reported doing both of these control measures, but in the studied fields many fruits, leaves or branches were infected, which shows that these measures are not followed thoroughly. Least vulnerable is a grafted hybrid, developed by the National Research Institute of Ecuador INIAP, which resists both the root rot *Meloidogyne incognita* and *Fusarium solani*. In general traditional cultivars are more susceptible to diseases. Recommended is the cultivar Común that shows a low susceptibility to diseases and a high acceptance of the consumers (INIAP, 2010).

Peas

In peas all farmers reported the "Lancha" as a major pathogen causing high losses. The disease could not be identified as there are many diseases associated with the Spanish name, which is generally used for fungal diseases. However, some plants showed symptoms of another fungal pathogen which was identified as Ascochyta blight (*Mycosphaerella pinodes* Berk and Blox. or *Ascochyta pisi* Lib.). Ascochyta blight can be controlled by plowing the stubbles down to deeper soil layers. The removal of crop residues is equally efficient. Furthermore there are resistant varieties, but also certified disease-free seeds can avoid disease outbreak (Infonet-Biovision, 2011).

In two fields a root rot was found in an irregular pattern, which indicates a soil-borne pathogen like *Fusarium wilt*. Fusarium wilt can be avoided with one of the many resistant varieties on the market. Few are resistant as well to Fusarium near wilt with very similar symptoms. The use of disease free seeds, certified or treated with a seed protecting fungicide is again an option. Residues can act as a reservoir of inoculum and should not get in contact with the newly planted crop. A five year rotation prevents a build-up of inoculum in the soil (University of Illinois, 1988). Over all few diseases occurred on peas. The plants were just before floration and more diseases may occur with pod formation and maturation. Most farmers did not use pesticides or mineral fertilizers in their pea crop.

Crop	Pest or disease	IPM measure
Potato	*Phytophthora infestans*	Resistant varieties combined with disease forecasting Avoiding Solanaceae in crop rotation
	Andean potato weevil	Plastic barriers
	Ralstonia solancearum	Resistant varieties Soil radiation Avoiding Solanaceae in crop rotation
	Potato tuber moth	*Bacillus thuringiensis* and PTM granulovirus Release of parasitoids *Copidosoma koehleri*, *Orgilus lepidus*, *Apanteles subandinus*
Tree tomato	Anthracnosis	Removal of infected and rotting fruits
	Fusarium solani	Prune infected branches
Pea	Ascochyta blight	Deep plowing of stubbles Resistant varieties
	Fusarium wilt	Crop rotation Resistant varieties

Table 2 IPM measures for present pests and diseases

Local methods used against pests and diseases

There are some methods used by the sampled farmers to combat pests and diseases organically, which also meet IPM/organic principles. Most common was the application of "Biol" as a spray. "Biol" is a mixture of the manure of cattle or other livestock, whey, sugar cane molasses (Panela), water, ash, baking soda and some herbs. It was found that the ingredients are not always identical; one version also contained pig urine, cow milk and an egg and others left out whey or sugar cane molasses. The following plant names were part of the mixture (missing Latin names are in Spanish or Kichwa): Rue (*Ruta* spec.), Eucalyptus (*Eucalyptus* spec.), angel's trumpet (*Brugmansia* spec.), Berro (*Nasturtium officinale* W.T. Aiton), Marco, stinging nettle (*Urtica* spec.), chili rocote (*Capsicum pubescens* Ruiz and Pav.), tobacco (*Nicotiana* spec.), alfalfa (*Medicago sativa* L.), peas with flowers (*Pisum sativum*) and vetch (*Vicia* spec.), chilca (*Baccharis latifolia*), garlic

(*Allium sativum* L.), verbena (*Verbena* spec.). The mixture is moved every two days and then left to ferment for some weeks. With the herbs included in the mixture it is a natural insecticide. Chili (Levinsohn, 1976), tobacco (Casanova *et al*., 2004), garlic (Tedeschi *et al*., 2011: 488, Debkirtaniya *et al*., 1980) and rue (Vaughan and Judd, 2006: 137) are known to be effective insect repellents. In *B. latifolia* Zapata *et al.* (2010: 103) found inhibiting effects of essential oils of *B. latifolia* against *Aspergillus fumigatus* Fresen and Roja *et al*. (2007) found an antibacterial effect against gram positive bacteria. Tobacco has been used for a long time to control insects, but its alkaloid alone is stated to not be very effective (Tomizawa & Casida, 2009: 262). One farmer reported using an ash against powdery mildew and fungal diseases of tree tomatoes and in potatoes. He would soak the ash in water, then sieve out the big particles and spray the ash water on the infected plants. By reducing the moisture and the bioactive components of the ash the survival rate of arriving and germinating spores could be smaller. Also, the ash particles probably occupy possible infection sites of pathogenic fungi and hinder an infection. However, these effects would only last until the next rain. The traditional crop "chocho" (a lupine variety) has high levels of alkaloids and has to be cooked several times to remove bitterness from the seeds. People in the area use the water leftover from cooking and spray their crops to combat pests.

State of the agroecosystem

The cropping area is located on and between the ridges of the mountain slope towards the Mojanda Lakes. The only flat land is located around Lake San Pablo. The land located here has a good water supply but in the higher altitudes agriculture is limited by the water supply and depends on rainfall. Cash crops like strawberries and tree tomatoes require irrigation and are planted close to the water sources. Other more traditional crops like quinoa, amaranth and maize are well adapted to the water scarcity. The water catchment of the *paramó* is channeled into the shrubs and then transported to the households in the villages. Only with excessive rainfalls the water reaches the lake. Yet terraces were not constructed to reduce the degree of slope and improve water holding capacity.

However, to reduce wind speed and erosion farmers constructed a wind protection with walls made out of adobe/loam called "Ardogón". They have been identified by the author as a habitat for soil inhabiting bees and bumblebees and contribute to pollination in the area. Hedges fulfil a similar function, including retention capacity for water and regulation of soil moisture content, and provide many services in an agronomic context as well as for nature conservation. In the research area hedges are abundant and can be found next to many fields. The natural vegetation has vanished in the intermediate altitudes. It has been replaced by Eucalyptus plantations, which is the case in other Andean regions as well (Carse, 2006). *Euphorbia laurifolia* ("Lechero") is the most planted shrub and believed to be a holy plant to the Kichwas. It is planted on the boundaries of the field and fulfils a protective function. The wood is never used for fire and the tree is highly respected (CEPCU, 2001). Other plants found in hedges are *Agave* spec., *Baccharis latifolia* Ruiz and Pav. ("Chilca"), Izzo (a 90cm high Fabaceae with blue flowers) and *Eucalyptus* spec. *B. Latifolia* is a fast growing shrub, 2m high and 3m wide.

They are used as a living fence and can fix soils on slopes and terraces (Efloras, 2008). *B. latifolia* seems to be of special interest to insects. Their flowers are visited manifolds. With 20 sweeps with an insect net 68 morpho species including 13 small wasp species, possibly parasitic, and 6 spider species were found, which shows the high biodiversity and its function in the ecosystem.

Conclusion

The Mojanda Watershed faces rainfall decreases in the future. The El Niño and La Niña phenomena are expected to increase in the future and weather patterns are expected to change. Traditional agricultural knowledge is at risk because planting calendars are adapted to the bimodal rainy-dry season and thus livelihood and financial outcome. These issues will be increased furthermore if the extension of the agricultural border into the *páramo* continues and its crucial water collection function diminishes. Decreasing precipitation concentrates the outputs of agriculture in the runoff water and pollution is expected to increase with current pesticide application praxis and type of pesticides applied (e.g. Carbofuran WHO class IB). Some products were banned in Europe and are even banned in Ecuador. With 68% of the questioned farmers there is a moderate level of pesticide users. However, 79% of the pesticide users applied them on a regular basis without checking for the pest or disease status and 26% did not know which products they apply. Knowledge about the pest and disease species, pest cycles is crucial to do regular scouting of their fields and to get the right timing for application to reduce pesticides and costs.

However, pesticides can also be replaced completely. There are some general methods included in the IPM principles to avoid a pest or a disease outbreak such as crop rotation, synchronous planting, certified seeds and the use of resistant cultivars. Crop rotation is always aimed at eliminating the pathogen from the soil either by time without the presence of the host of the pathogen or by antagonistic characteristics of plants which can accelerate this process. Suppressive soils can increase the effect where antagonistic microorganisms block out the pathogens. Synchronous planting enhances the effect of crop rotation when a whole area follows the same rotation. If resistant varieties are available they are the most powerful tool. Tree tomatoes do not have a very broad distribution and resistant varieties do not exist for the anthracnosis, which reduces yields substantially. The only alternative to pesticides is to collect the infected fruits or to test other products already applied in other crops.

Local farmers have been shown to use some alternatives to combat pests like the preparation of "Biol", the application of left-over water from cooking chochos or the spraying against fungal diseases with an aqueous solution of wood ash. Especially "Biol" seems to be an effective bio pesticide. Yet the recipe differs and the formulation could be optimized in further research to distribute the knowledge or the product as a cheap alternative to pesticides. For other, commercially available and ecological sound, pesticides or biocontrol agents like PTM granulovirus, Btk or parasitoids the farmers may not be able to have access. Public institutions if not the pesticide sellers are challenged to provide these inputs. The same is valid for certified seeds. For traditional crops certified seeds are less important than for non-traditional crops as they usually show a high adaption to the environment. An interesting IPM method against the weevil was found to be plastic barriers around the fields. If seed potatoes are checked for an infestation, the barriers prevent the flightless weevils from migrating onto the fields (Kuschel, 2009).

With education it is possible to reduce pesticide pollution. IPM methods require substantial knowledge on the farmer's side. Farmers in the study area are only educated at a basic level and furthermore they lack access to information about agricultural practices and the agricultural market.

People in the region reported about lower yields compared to previous years (Wales, 2012). The fallow time has been reduced and does not seem to allow the fields to restore the soil fertility. Applied fertilizers do not seem to replace extracted nutrients either and erosion plays another role in the reduction of soil fertility. The NGO CEPCU (2001) had already observed erosion in the most cultivated parts between 2700 m a.s.l and 3200 m a.s.l..

The people of the Mojanda watershed live in a fragile ecosystem. Water is at the centre of attention and its quantity and quality are at risk. Agriculture is connected highly with the identity of the people, yet the financial outcome is marginal. Extension service could mitigate agricultural problems and push forward more sustainable farming practices, but to solve the situation a development plan for the region is needed to reduce the pressure on the land and the people and water resources.

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Drinking water issues in Rural India: Need for stakeholders' participation in Water resources management

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Abstract
Water is a very essential livelihood for mankind. The United Nations suggest that each person needs 20-50 litres of water a day to ensure basic needs of drinking, cooking and cleaning. It was also endorsed by the Indian National Water Policy 2002, with the provision that adequate safe drinking water facilities should be provided to the entire population both in urban and in rural areas. About 1.42 million rural habitations in India are affected by chemical contamination. The provision of clean drinking water has been given priority in the Constitution of India, in Article 47 conferring the duty of providing clean drinking water and improving public health standards to the State. Excessive dependence of ground water results in depletion of ground water, water contamination and water borne diseases. Thus, access to safe and reliable water supply is one of the serious concerns in rural water supply programme. Though government has taken certain serious steps in addressing the drinking water issues in rural areas, still there is a huge gap between demand and supply. The Draft National Water Policy 2012 also states that Water quality and quantity are interlinked and need to be managed in an integrated manner and with Stakeholder participation. Water Resources Management aims at optimizing the available natural water flows, including surface water and groundwater, to satisfy competing needs. The World Bank also emphasizes managing water resources, strengthening institutions, identifying and implementing measures of improving water governance and increasing the efficiency of water use. Therefore stakeholders' participation is viewed important in managing water resources at different levels and range. This paper attempts to reflect on drinking water issues in rural India, and highlights the significance of Integrated Water Resource Management as the significant part of Millennium Development Goals; and Stakeholders' participation in water resources management.

Keywords: *Access to safe water; Stakeholder participation; Water Resources Management; Integrated Water Resources Management; Millennium Development Goals*

Introduction

India is a country known for its rich cultural association with water. All natural resources are respected and most particularly the rivers in India are worshiped on par with Goddesses. Rivers are also the sites of the evolution of major cultural complexes. India is blessed with abundant natural resources especially water, which are used for various purposes predominantly agricultural followed by domestic and industrial purposes.

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The different types of water resources in India include rivers, lakes, ponds, canals, tube wells, open wells and springs. But the problem is of space and time distribution of those water resources. The country has 16 percent of the total population of the world but has only 4 percent of the water resources present on the earth. It has only 2.5 percent, out of the total geographic are of the world. It receives approximately 1100 millimetre average rain fall annually, however it is irregular and only during a limited period of two to three months (Gautam and Kumar, 2005). India's water resources significantly depend on monsoon rains; but at the same time, the country has a big population, large area of irrigated agriculture land and considerable industrial operation which generates high demand for water (Gosh Roy, 2011). Presently almost 80 per cent of drinking water needs are met from ground water. By 2050 the demand for water has been projected as 1180 bcm. It means all the utilizable water resources will have to be put to use by 2050 to meet the demand. Water demand will increase due to increases in population. Apart from a population bulge, greater use of energy, depletion of ground water resource, lack of awareness on water usage among the users, increased growth in packaged/bottled water, implementing deficiencies in water management mechanisms and lacunas in administering this scarce resource will adversely affect fresh water availability in India.

Despite the significant role of water in the lives of Indians awareness about handling water and its optimal usage are very poor. The Indian constitution (article 47) and Universal Declaration of Human Rights (Article 31) emphasize the fundamental rights to clean and accessible water to acknowledge human dignity. Since Independence numbers of integrated drinking water supply programmes have been implemented by the central and State Governments of India to fulfil the water needs of its citizens. Generally there is a perception among the citizens that water is a free commodity or common property and so that government is the service provider. It expects government to be more responsible of delivery issues, at the abdicating its own responsibility. Accountability and participation are less valued by the citizens thus hampering sustainable use of water. Water resources need to be protected and augmented and well managed with collective efforts for sustainability. In rural India water resources management is only possible with stakeholders' participation. Panchayat Raj Institutions (PRIs)[1] are the local governing authorities who play a vital role in enhancing community participation at village levels. Hence, there is an urgent need to enhance stakeholders' participation at different levels for water availability, accessibility, maintaining quality, sustainability, delivery and distribution. This paper attempts to examine the water issues in rural India, various rural water supply programmes, National Water Policy and the role of Panchayat Raj Institutions and the importance of stakeholders' participation towards sustainable water resources management with reference to the empirical study findings carried out by the researcher on Water Governance practices in Thiruvallur District, Tamil Nadu, India. Geographically Tamil Nadu is the eleventh largest state (50,216 Sq. Km) and ranked in top 6th in Human

[1] In India, Panchayati Raj system is a three-tier system in the state with elected bodies at the Village, Taluk and District levels. It ensures greater participation of people and more effective implementation of rural development programmes. There will be a Grama Panchayat for a village or group of villages, a Taluk level and the Zilla Panchayat at the district level.

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Development Index, 2011 and the population is 72,147,030 as per Census 2011.

Drinking water issues and implications in rural India

Water scarcity is a serious issue in India. The 2001 census data confirms that 68.2% of households have access to safe drinking water[2]. The Department of Drinking Water Supply (DDWS) estimates that 94% of rural habitations and 91% of urban households have access to drinking water. But according to the experts these figures are misleading simply because coverage refers to installed capacity and not actual supply. The ground reality is that of the 1.42 million villages in India, the water resources of 195,813 villages are chemically contaminated. The quality of ground water that accounts for more than 85% of domestic supply is a major problem in many areas as none of the rivers has water fit to drink. High Nitrate content in water is another serious concern. Fertilizers, septic tanks, sewage tanks are the main sources of Nitrate contamination. In India, water quality is another serious problem with its states. The groundwater in the state of Maharashtra, Uttar Pradesh, Punjab, Haryana, Delhi, Karnataka and Tamil Nadu has shown considerable traces of Nitrates. The southern state of Tamil Nadu accounts for 4 percent of the total land area of the country and 6 percent of its total population, but has only 3 percent of the water resources of the country. Till the 10th five year plan the government had spent Rs.1, 105 billion on drinking water schemes. [3]

The norms being adopted for providing drinking water to rural populations in the habitation [4] are: 40 litres per capita per day (lpcd), 30 lpcd additional for cattle in Desert Development Programme (DDP) areas, one hand pump for every 250 persons, potable water sources within 1.6 km in plains or 100 metres elevation in hilly areas. In view of the gigantic task involved to provide drinking water as per norms, the Government of India has now ordered a fresh nationwide survey to enable it to take a comprehensive view. Besides drinking water supply the emphasis has to be on quality of water as well (Karalay, 2005). In the rural water supply section habitations are classified as not covered and fully covered. Not covered habitation is one which has no public or private drinking water sources point within 1.6 km of the habitation in plain area or 100 m elevation in hilly area. One of the problems being faced in the rural drinking water sector is the slippage of habitations from fully covered to partially covered and partially covered to not covered habitations due to increase in population, fall in ground water, water quality problems namely, fluoride, arsenic, iron, nitrates and bacteriological contamination. Absence of clean drinking water, leads to epidemics like cholera and gastroenteritis. The World Bank estimates that 21% of communicable diseases in India are related to unsafe water. Thus the social cultural factors

[2] Reference to “Drinking water quality in rural India: Issues and approaches Background” Paperhttp://www.wateraid.org/~/media/Publications/drinking-water-quality-rural-india.pdf

[3] Reference to “Water problem in India” http://www.azadindia.org/social-issues/water-problem-in-india.html

[4] A rural habitation is defined as a locality within a village where a cluster of families reside. The total population should be 100 or more for consideration for coverage under the rural water supply norms

include household size, consumption of the household level of education, average age of the household head, area or origin of the household among others, household sizes influence the demand for water from two angles. On the one hand it directly influences the total demand for water in the household, while on the other hand it reduces the per capita use (Reddy and Dev, 2005).

A study report on the assessment on Water Supply and Sanitation jointly conducted by Planning Commission of India, the Word Health Organization (WHO) and the United Nations Children's Fund (UNICEF) in the year 2002, suggests that the adoption of a demand driven approach and empowerment of villages; a focus on village-level capacity building, the maintenance of an integrated approach to water supply and sanitation and hygiene promotion; a requirement for partial capital cost recovery and full operation and maintenance financing users; the promotion of ground water conservation and rainwater harvesting are the various ways to enhance community participation towards drinking water issues (Van Dijik and Sijibesma 2006).

Rural water supply programmes and challenges and Role of Panchayat Raj Institutions

Early days drinking water supply in rural areas are perceived as outside the government purview. The traditional sources of drinking water in rural areas were namely, community managed open wells, private wells, ponds, river, lake and small scale irrigation reservoir. The rural water supply programmes were implemented since the 1950s.[5] The Central Government investment in the rural water supply programmes is huge. The Accelerated Rural Water Supply Programme was launched in 1972-73. Followed by Sector Development, the technology mission renamed as Rajiv Gandhi National Drinking Water Mission (RGNDWM) in the year (1991-92) emphasized water quality, technology and Human Resources Development. Between 1999-2000, a new initiative was taken to involve the community at planning, implementation and management of Rural Water Supply Schemes.

Later in 2002 the *Swajaldhara*[6] was scaled up by considering the initiatives taken in the year 1990's-, such as Sector Reform Project which become crucial in framing Swajaldhara guidelines. The National Rural Drinking Water Programme (NRDWP) is an initiative of the Department of Drinking Water supply, Ministry of Rural Development Government of India, sprung up during the Tenth Plan to ensure people drinking water scarcity in rural areas at household level with community participation and Panchayat Raj Institutions, to deal the issue of sustainability of source and system and ensuring potable water. The (NRDWP) viewed water as a public good and basic need. It also ensures to change the perception of Conventional 40 Litre Per Capita Day (lpcd) norms into drinking water security at community level. However, households are the basic units of the community. It is also projected that by 2022 every person should have

[5] Rajiv Gandhi National Drinking Water Mission, Department of Drinking Water Supply, Ministry of Rural Development, Government of India, 2010

[6] Swajaldhara is a centrally sponsored rural water supply scheme launched in 2002 for enhancing community participation

70 lpcd within 50 meter from their households.

Water supply and sanitation is the basic responsibility of the state under the Constitution of India and following the 73rd and 74th Constitutional Amendments, the States may give the responsibility and powers to the Panchayati Raj institutions (PRIs) and Urban Local Bodies (ULBs).[7] The Though State/Central Governments are taking necessary steps to address the issue of water scarcity in rural areas like policy formulation, planning, designing and executing water supply schemes and coordination and harmonization of standards yet there are some challenges which often affect the rural masses to exercise their fundamental rights.

The issues related to water quality, availability, reliability and sustainability are the challenges ahead to the State and Central Governments. In India the perennial surface water resources, rivers and streams are wiped out due to over use and extraction. Water scarcity occurs when the supply of water is unable to meet demand. Climate change is also another human included stress. Low water tariffs/unpaid tariff have left the finances of most the local bodies in very bad shape leaving no maintenance and no new developments. Public opinion of water as a practically free commodity at free of cost is yet to change. The system of drinking water supply in rural areas is drawing attention and gaining momentum after the PRIs came into reality. It is the pressing issue of the people and the elected members of PRIs as they primarily focus on the subject of rural water supply vests with Panchayat Raj Institutions (PRIs). The Panchayats play a major role in providing safe drinking water and managing the water systems and resources (Sharma et al, 2008). Therefore, PRIs/local bodies must be empowered to take up operation and maintenance activities related to rural water supply systems. Providing capacity building to local communities by giving requisite training to pump operators, community based organizations especially Village Water and Sanitation Committee, Self Help Group women to operate and maintain hand-pumps and the components of other water supply systems as well as to generate demand for adequate sanitation facilities.

Women: Stake Holders at Challenges

Even though many water supply schemes are implemented in India, the precious time of women is at stake due to them having to spend their time fetching water or waiting at the source/supply without even knowing when and how long the water will be available. There are lots of unmet needs concerning water for the people. The culture of safe drinking water has to be stressed as the disease burden is mostly water related. The water bodies are to be conserved with the participation of the people particularly women and the youth. The habit of safe drinking water is to be developed and periodically the quality testing of water with public knowledge and public involvement is to be inculcated. There is less water equity in rural India and the marginalized and poor are affected as they are forced to drink the available unsafe water which harms their health. Making available safe water is a governance as well as human right issue as it is right to a safe life. Therefore the welfare state and the PRIs have to take it on themselves as the priority and the foremost responsibility.

[7] Study report on the assessment on Water Supply and Sanitation jointly conducted by Planning Commission of India, the WHO and UNICEF.

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The Projected population in million in the years are		
Year	**Population in Million**	**Per capita availability in cubic meter**
2025	1394	1341
2050	1640	1140

Table 1 Per capita availability of water in India, Source: Singh, 2006

National Water policies of India

The National Water Policy (NWP) is the primary document stating the position of the Government of India (GOI) on water resource issues ranging from drought and flood management to drinking water provision. The NWP serves as a guideline to help planners and managers develop the country's water resources to their maximum potential. It also stresses the development of comprehensive water data system, basin/sub-basin wise water planning watershed management, fixation of water allocation priorities, enhancing, project planning and implementation capabilities, the achieving of sustainability in the uses of ground water in conjunction with surface water ensuring that drinking water needs are met, integration of water and land use policies, adequate financial allocations for water programmes and time bound implementation of such projects. The document specially underlines conservation, integrated use of land and water, participatory management, better floods control and management practices and appropriate legal framework for water sharing and distribution among states regions and all stakeholders (Dhar, 2003).

The first National Water Policy was devised in 1987 and drinking water was given utmost priority. The National Water Policy-2002 advocates that water is a prime natural resource, a basic human need and a precious national asset need to be governed by national perspectives and planned, developed, conserved and managed on an integrated and environmentally sound basis. It has also insisted the paradigm shift in the management and improving the performance of existing water resources (Ghosh Roy, 2011). The present Draft National Water Policy-2012 endorses that water is a natural resource, fundamental to life, livelihood, food security and sustainable development. Water is viewed as a scarce resource. Water mismanagement and climate change led to water scarcity. The immediate concern is to have a legal framework to ensure holistic and balanced development. The significance of Integrated Water Resources Management (IWRM) is viewed as a main principle of planning, development and management of water resources. The National Water Policies 2002 and 2012 endorse the role of PRIs in Water Resources Management.

Integrated Water Resource Management adaptation in India

Water is a natural resource that has to be harnessed, treated, used and conserved collectively by all the users. Making it available and participation are keys. Management means coordination of activities to achieve the defined objectives. The classical theories of Management namely, Administrative Management theory of Henry Fayol and Behavioural approaches of Hawthorne

Studies 1930s emphasizes the participatory planning and significance of human relationship for successful management, and the importance of water which is one of the physiological needs stated by Abraham Maslow.[8] Water resource management is the activity of planning, developing, distributing and managing the optimum use of water resources. The Global Water Partnership (GWP) defines that Integrated Water Resources Management (IWRM) is a process which promotes the coordinated development and management of water land and related resources in order to maximize economic and social welfare in an equitable manner without comprising the sustainability of vital eco systems and the environment.[9]

Water management in irrigation or efficient utilization of the water will also increase crop intensity and productivity and suitable crop pattern (Sen & Das 1986). Water is important for food production. If water resources are not managed well, it will become a major constraint to the achievement of food security.

The way forward for efficient, equitable and sustainable development and management is internationally accepted. Democratic participation in governance and human health is demanded. It is designed to replace the traditional, fragmented-sectoral approach. IWRM in taking river basin / sub-basin as a unit should be the main principle for planning, development and management of water resources. But in reality, lack of integration between sectoral water-related policies, which leads to fragmented programs and inefficient utilization of technical capacities and financial resources, lack of decentralization and efficient local administrative structures, coupled with low capacity in end-users, which minimises the opportunities to operationalise IWRM at the grass root level.[10] Thus, the concerned departments, organizations at Centre-State Governments levels should be restructured and made multi-disciplinary accordingly.

The Indian scenario depicts that the availability of water in adequate quantity is also a challenge throughout the day. The analytical framework of IWRM at the macro level insists on the inter-sectoral approach and the implementation of the Inter-ministerial coordination. In India a central Ground Water Authority has been constituted under the Environmental Protection Act to serve as a monitoring body which has a greater responsibility towards the water sustainability at macro level. Community participation at different levels is also important to put the concept of IWRM in-to practice. The analytical framework of IWRM also emphasizes the changes in the utilization and availability of the water resources and in the water resources system itself and it may be applied at the micro level i.e. at village-level for the coordinated efforts that are needed to promote the water resources development.[11] India has not yet reached the level of Water Resources Development as has already been achieved by many developed countries;

[8] Reference to "Management, theories, roles, motivations and communications", http://www.engr.sjsu.edu/epeterson/Avia179/docs/Chap3.pdf

[9] GWP Technical Advisory Committee, 2000. TAC Background Paper Number 4.Integrated Water Resources Management

[10] Integrated Water Resources Management Planning Approach for Small Island Developing States

[11] Analytical Framework for the Planning of Integrated Water Resources Management.

therefore, there is a need for India to undertake developmental measures along with management measures (Draft Guide line for IWRM, 2010)

International Conventions and Millennium Development Goals and its relevance in rural India

The UN Water Conference, in 1977 passed a resolution on the right to have access to water. In Rio-Brazil in 1992 – the World Summit on sustainable Development - emphasized the protection and quality of fresh water resources as one of the main activities of sustainable development. Ministerial Declaration at the second World Water Forum in the Hague in March 2000 and the deliberations at 3rd World Water Forum at Kyoto in March 2003, also called upon nationals towards water security in the 21st Century and make water as every-body's business. Ministerial Declaration at Freshwater Meet in Bonn 2001 placed greater commitment on agreed principles of water resources management and called upon for new partnership to create water wisdom, cleaning up water sheds to reaching communities and innovative solution for sustainable use, protection and management of fresh water. The International Conference on Water and Environment in Dublin, Ireland in January 1992 also gave rise to four principles in bringing reform in the water sector.

International organizations such as the World Bank, Asian Development Bank, United Nations, World Water Council and Global Water Partnership also emphasizes the importance of the protection of fresh water resources and its sustainability through community participation. Further the Millennium Declaration of the UN has stressed the global goal of halving the population without sustainable access to water supply and sanitation by 2015. Thus water management is the key to achieve the MDGs. It is also highly stressed by the MDGs that safe and secured water supply will enable all the groups in a community for active participation towards water resource management.[12]

Furthermore, the objectives of the MDGs and human rights namely, to preserve and protect human dignity ascertain that access to water is a basic human right. *Article 47* in the *Constitution* of *India* 1949 confers the duty of the State to raise the level of nutrition and the standard of living and to improve public health and the constitutional right to access to clean drinking water can be drawn from the right to food, the right to clean environment and the right to health, all of which have been protected under the broad rubric of the Right to Life guaranteed under Article 21 of the constitution. In addition to article 21, Article 39 (b) of the Directive Principles of State Policy (DPSP), which the Constitution declares to be non-justiciable, recognizes the principle of equal access to the material resources of the community. Article 39 (b) and states that 'the State shall, in particular, direct its policy towards securing that the ownership and control of the material resources of the community are so distributed as best to sub serve the common good'.[13] India is committed to the MDGs. Drinking water is relevant in most of the MDG goals as water is central to health and development and to be disease free. It is very much possible to bring drinking water to everyone with prioritizing, planning funding with stakeholders' participation

[12] The Millennium Development Goals And Human Rights, the UN Millennium Campaign , Research and Right to Development Division, Office of the UN High Commissioner for Human Rights, Switzerland

[13] Jayna Kothari (2006), The Right to Water: A Constitutional Perspective

and with government providing services to the neglected and deprived population.

Participation of Stakeholders in Water Resources Management

Stakeholders are those who fall in to three categories like primary stakeholders (affected population) secondary stakeholders (local authorities) and tertiary/external stakeholders (agencies). The stakeholders have roles and a say in water resources management. The stakeholders' participation is democratized when they participate in the water decision-making and water related activities take place through public hearings, stakeholder involvement in administrative bodies, organization of user associations and for general environmental concerns, a greater permissiveness in the rules governing standing to act in either administrative or judicial forum. Thus, stakeholders may participate in policy making, legislative discussion, general water administration, and field level activities (Solanes and Villarreal, 1999).

One of the guiding principles of the Dublin statement on water and sustainable development also envisages (Miguel Solanes and Fernando Gonzalez-Villarreal, 1999) stakeholders' participation at different levels. It is also emphasized in the National Water Policy-2002, India that the stakeholders' need to participate in water resource management. Hence there is an urgent need to ensure stakeholders' participation in the revival of water resources, water handling practices and their participation at all levels to ensure sustainable water resource management. In India though the stakeholders' participation is envisaged through Gram Sabha at the Panchayat level but is still the congenial environment to participation and is not there in the country due to lesser sensitivity, lack of social equity social and caste classification or stratification. The rights based approach is to be followed in drinking water rather than it being an entitlement.

Empirical Evidence

The first author conducted a research study on "Water Governance Practices in Thiruvallur District Tamil Nadu", India to understand the role of governing authorities, the benefits of rural water supply programmes, the availability of water resources, access to water, water demand and participation of the stakeholders in the revival of water resources. She had interviewed 260 respondents (122 males and 138 females) from six Village Panchayats. Mixed methods were used like a structured interview schedule, focus group discussions, participant observation and social mapping to find the facts. The service providers' namely, elected members (Panchayat Presidents), Government officials (Engineers from Tamil Nadu Water Supply and Sewerage Board) and members or office bearers of Community Based Organizations (CBOs) were also interviewed by the author.

Study Findings

This study reveals that the stakeholders need to be given information, education and communication (IEC) and training on water resources management. The local governing authorities and community based organizations play a pivotal role in service delivery and rejuvenation of the water resources. It was also found that one third of the respondents depend on a variety of sources to meet their water supply requirements. A few have their own well or bore well. Others take water from their neighbours or from neighbouring communities. A few respondents even trek to the next village to tap the resources there. However, nearly three fourths manage with the locally available resources. Nearly a third had complaints about the colour, salinity and odour of the drinking water supplied to them. Colour is the most common complaint followed by salinity and bad odour. The results are illustrated in Figure1. The result with numerical data is enclosed in the Annexure. Figure 1 shows that more than half of the respondents have access to water at least two times a day. About a third are less fortunate as they can avail it only every other day or even at less frequent intervals.

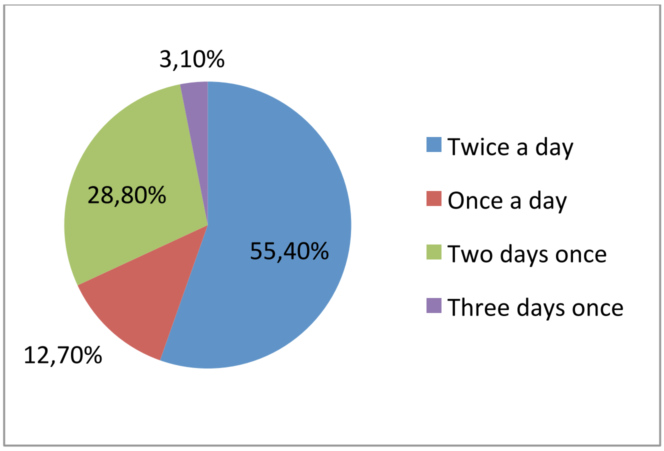


Figure 1 Frequency of water availability in the respondents' locality

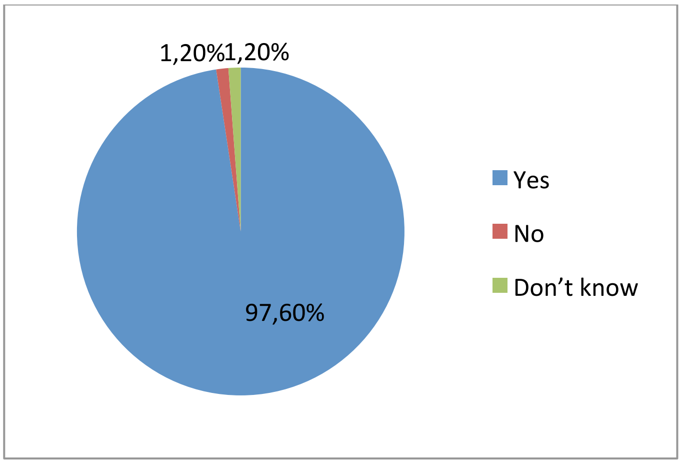


Figure 2 Respondents' view of water as a public good

Figure 2 depicts the attitude of the respondents towards water. An overwhelming proportion (97.6%) of the respondents feels that they view water as public good. It means that the community felt that it is the responsibility of the government to provide water free to the residents of the community and they need not pay for it. It is revealed from Figure 3 that nearly 25 percent of the respondents feel that there is a need for revitalization and conservation of water resources. Others do not think so. Perhaps they may not be aware of the importance of water conservation and they must be educated on that. Nearly 25 percent of the respondents have adopted useful

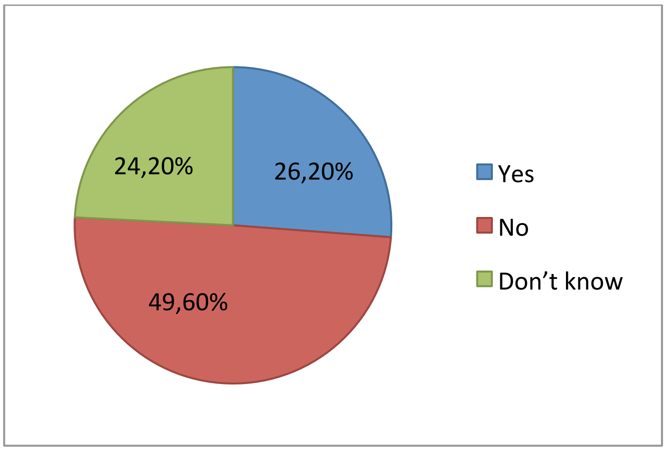
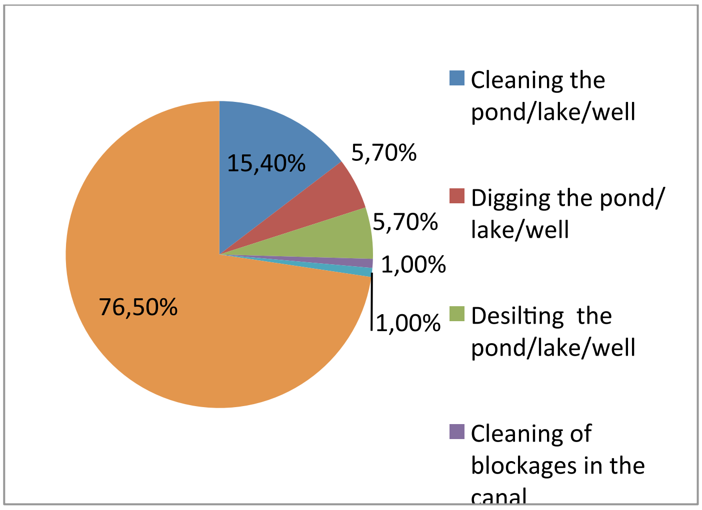


Figure 3 Respondents' opinion about revival and conservation of water resources in their locality



*Multiple response N=260

Figure 4 Type of measures taken by the respondents towards revitalizing water sources

measures of conservation and revitalization such as cleaning up, desilting and sinking new wells (Figure 4). The large number (76.5%) said that they did not think about it. Thus this segment of the population needs to be made aware of water management or managed to build its capacity and understand the importance of rejuvenating the water resources to meet water demands in future.

Discussions

This study reveals that more than half of the respondents get water twice a day whereas others (28.8%) get two days once and three days once (3.1%) and this shows lack of access to drinking water for them. These findings correlate with the conclusions of Hardener Raj Gautam's study (2009). Gautam notes that water is the very basis for the existence of human as well as all other forms of life (Gautam2009). Access to safe water and sanitation is a critical socially and economically and in many cases a political issue, which determines the health of individuals and communities and the productivity of nations.

In India more than 700 million people live in about 1.42 million habitations spread over diverse ecological regions. Meeting drinking water needs of such a large population can be a daunting task especially in the backdrop of different level of awareness, disparities in socio-economic development, education, and poverty, a range of practices and rituals and water availability. It was found that nearly half of the respondents (49.6%) did not think about revival of water sources in their locality. This shows their lack of awareness about water conservation and water resources management. Thus these people need to be given training on water resources management. Archana Mishra, (2006) articulates that water Resources Management is an integrating concept for a number of water sub-sectors such as hydro power, waste supply and sanitation, irrigation and drainage, and environment. The integrated water resources perspective ensures that social, economic, environmental and technical dimensions are taken into account in the management and development of water resources. The study findings reveals that about a third are less fortunate access towards potable water as they can avail it only every other day or even at less frequent intervals. At village level, as per the Amendment to the Constitution of India, the subject of rural water supply rests with the Panchayati Raj Institutions (PRIs). The Panchayats are to play a major role in providing safe drinking water and managing the water system sources (Thapliyal et al, 2008). Hence they have greater say in providing water to the citizens with equity and justice.

This study further reveals that a small percentage (23.5%) of the respondents at least have taken steps to revitalize the water resources whereas the majority of 76.5 percent did not even think about it. Efficient management of water only will pave the way for sustainable development. The eleventh Five year Plan (2007-2012) states that the sustainable development and efficient management of water is an increasingly complex challenge in India. India with 2.4% of the world's total and 16% - of the world's population has only 4% of the total available fresh water. This clearly indicates the need for water resource development, conservation and optimum use.

In order to address the issue of water crisis the people need to be motivated to participate in the water resources management activities or schemes related to water management implemented by government and other agencies. Mishra (2006) has emphasized the important of people's participation in rain water harvesting. Furthermore Mishra says that it is becoming more widely accepted that unless people are actively involved in the development projects which are aimed to help them, the projects are doomed to fail. It is important that the beneficiaries participate in every stage of the project. When the project is being planned, people should be consulted, and their priorities and needs assessed. During the construction phase people again should be involved supplying labour but also helping with field layouts after being trained with simple surveying instruments.

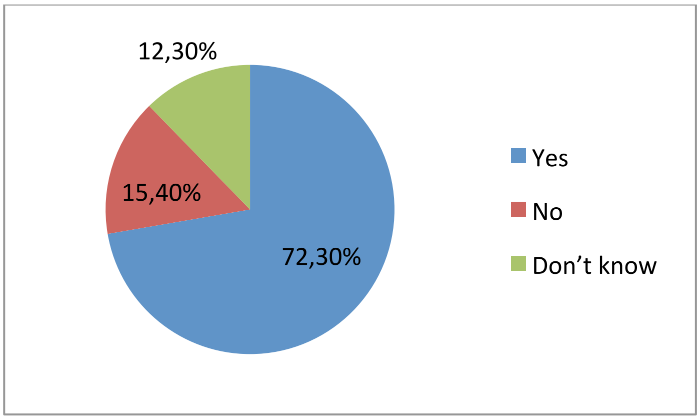


Figure 5 Respondents' opinion on provision of IEC resources for better household water practices

Figure 5 explains that 72.3 percent of the respondents realized the importance of provision of IEC resources for better household water practices. This indicates that community need to be empowered though water literacy for better water management at household levels.

Suggestions and conclusion

In rural India the system of administration is well established with the jurisdiction of a geographical area called the District. The District is the administration as well as planning unit and further divided into development blocks and currently the Panchayats and towns and urban local bodies are added from the effective decentralization. At the district level instead of Departments, water authorities were created for the faster decision making and autonomy. Predominantly the water resources for drinking purpose depended on the local resources and certain regions may have larger drinking water projects covering larger area transcending districts including externally aided (World Bank funded). With gradual awareness and better functioning of local bodies and by questioning, discussion and deliberations and debate in the Gram Sabha meetings would make the system function effective and accountable particularly in water governance. The information on water availability, reliability, quality and quantity needs to be shared with households, community based organizations, Anganwadi[14] schools and other learning institutions for ensuring community participation at all levels. With the average 2% annual growth of the population and migration both in and out, has to be taken into account while planning.

As participation commences from the planning level, it must be encouraged at grass root level which can never be compromised. People with the vast local knowledge and knowing the ways to revitalize the water resources may also be encouraged and need to be connected with Information, Communication and Technology (ICT). The district level planning committee needs to be educated and refreshed with various

[14] The word Anganwadi means "courtyard shelter" in Hindi. They were started by the Indian government in 1975 as part of the Integrated Child Development Services program to combat child hunger and malnutrition.

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levels of interaction has to focus and make even futuristic goals taking into account of development and management of water resources. The committee at various levels should consciously assess the source supply and plan for the future. They should ensure every year there is augmentation of drinking water as well as taking into account the climate change impact and also vulnerability of the district to flood and drought and other disasters which affects the drinking water availability. The impact of climate change on agriculture could result in problems with food security and may threaten the livelihood activities upon which much of the population depends. Drinking water availability and supply is also energy related aspect, hence that also become part of the drinking water management. The district should plan in such a way in to fulfil the set targets and may strive to achieve the standards prescribed by World Health Organization.

There are districts of different types like hill districts, flood prone districts, cyclone prone, drought prone districts and multiple disaster prone districts. These must be given greater importance in the provision of portable water according to rural water supply norms. Women are the household managers and have a greater role in water management and so need to be sensitized towards better water handling practices. Youth and other potential human resources need to be encouraged towards revitalizations of water resources, water budgeting and water auditing. Water literacy needs to be enhanced by discussion, debate, in the Gram Sabha meetings and in common forum. The observation of world water day would create awareness among the community on water scarcity and a need for water management. Water resources mapping, assessment and planning, water budgeting, auditing and law enforcement in user charge payments, use of the latest technology and structures, water conservation measures, revival of water resources and traditional knowledge on water harvesting must be done by community based organizations for collective action and PRIs should be responsible authority for maintenance. Government must change its role from service provider to the facilitator to involve stakeholders' participation. The community needs to be empowered through capacity building training programmes by trained personnel's like community development specialists to understand the water related issues and act collectively towards water resources management.

Acknowledgement

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Appendix

The following tables reveal the study results with numerical data;

S. No.	Frequency of water availability	Frequency	Percentage
1.	Twice a day	144	55.4%
2	Once a day	33	12.7%
3	Two days once	75	28.8%
4	Three days once	08	3.1%
	Total	260	100.0%

Table 1 Frequency of water availability in the respondents' locality

S. No.	Public Good	Frequency	Percentage
1.	Yes	254	97.6%
2	No	3	1.2%
3	Don't know	3	1.2%
	Total	260	100.0%

Table 2 Respondents' view of water as a public good

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S. No.	Opinion about revival and conservation of water resources	Frequency	Percentage
1.	Yes	68	26.2%
2	No	129	49.6%
3	Don't know	63	24.2%
	Total	260	100.0%

Table 3 Respondents' opinion about revival and conservation of water resources in their locality

S. No.	Type of measures	Frequency	Percentage
1.	Cleaning the pond/lake/well	43	15.4%
2	Digging the pond/lake/well	16	5.7%
3	Desilting the pond/lake/well	16	5.7%
4	Cleaning of blockages in the canal	3	1.0%
5	Others	3	1.0%
6	Not applicable	99	76.5%
	Total	280*	100.0%

*Multiple response N=260

Table 4 Type of measures taken by the respondents towards revitalizing water sources

S. No.	Opinion	Frequency	Percentage
1.	Yes	188	72.3%
2	No	40	15.4%
3	Don't know	32	12.3%
Total		260	100.0%

Table 5 Respondents' opinion on provision of IEC resources for better household water practices

Wastewater usage in urban and peri-urban agricultural production systems: scenarios from India

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Abstract
The role urban and peri-urban agriculture (UPA) plays in reducing urban poverty and ensuring environmental sustainability was recognized by the Millennium Development Goals (MGDs). India is the world's largest democratic nation with a population of 1.2 billion. The rapid urbanization and high proportion of people below the poverty line along with higher migration to urban areas make India vulnerable to food crisis and urbanization of poverty. Ensuring jobs and food security among urban poor is a major challenge in India. The role of UPA can be well explained and understood in this context. This paper focuses on the current situation of UPA production in India with special attention to wastewater irrigation. This question is being posed about the various human health risks from wastewater irrigation which are faced by farmers and labourers, and, secondly by consumers. The possible health hazards involve microbial pathogens as well as helminth (intestinal parasites). Based on primary and secondary data, this paper attempts to confirm that UPA is one of the best options to address increasing urban food demand and can serve to complement rural supply chains and reduce ecological food prints in India. "Good practice urban and peri-urban agriculture" necessitates an integrated approach with suitable risk reduction mechanisms to improve the efficiency and safety of UPA production.

Keywords: *Health risks; Millennium Development Goals; Urban and peri-urban agriculture; Wastewater use*

Introduction

The significant role of urban and peri-urban agriculture (UPA) in the fulfilment of the Millennium Development Goals (MGDs), especially reducing urban poverty and hunger (MDG 1) and ensuring environmental sustainability (MGD 7), has been well recognized (Von Braun *et al.*, 2004; Mougeot, 2005). "Urban and peri-urban agriculture can be broadly defined as the production, processing and distribution of foodstuff from crop and animal production, fish, and ornamental flowers within and around urban areas" (Mougot, 2000). UPA production systems were based on intensive and high input management practices on scarce lands (Smith *et al.*, 1996; Pearson *et al.*, 2010)

Vazhacharickal, Prem Jose., and Gangopadhyay, Sumita Gupta. (2014). Wastewater usage in urban and peri-urban agricultural production systems: scenarios from India. *Future of Food*: *Future of Food: Journal on Food, Agriculture and Society*.2(1): 111-133
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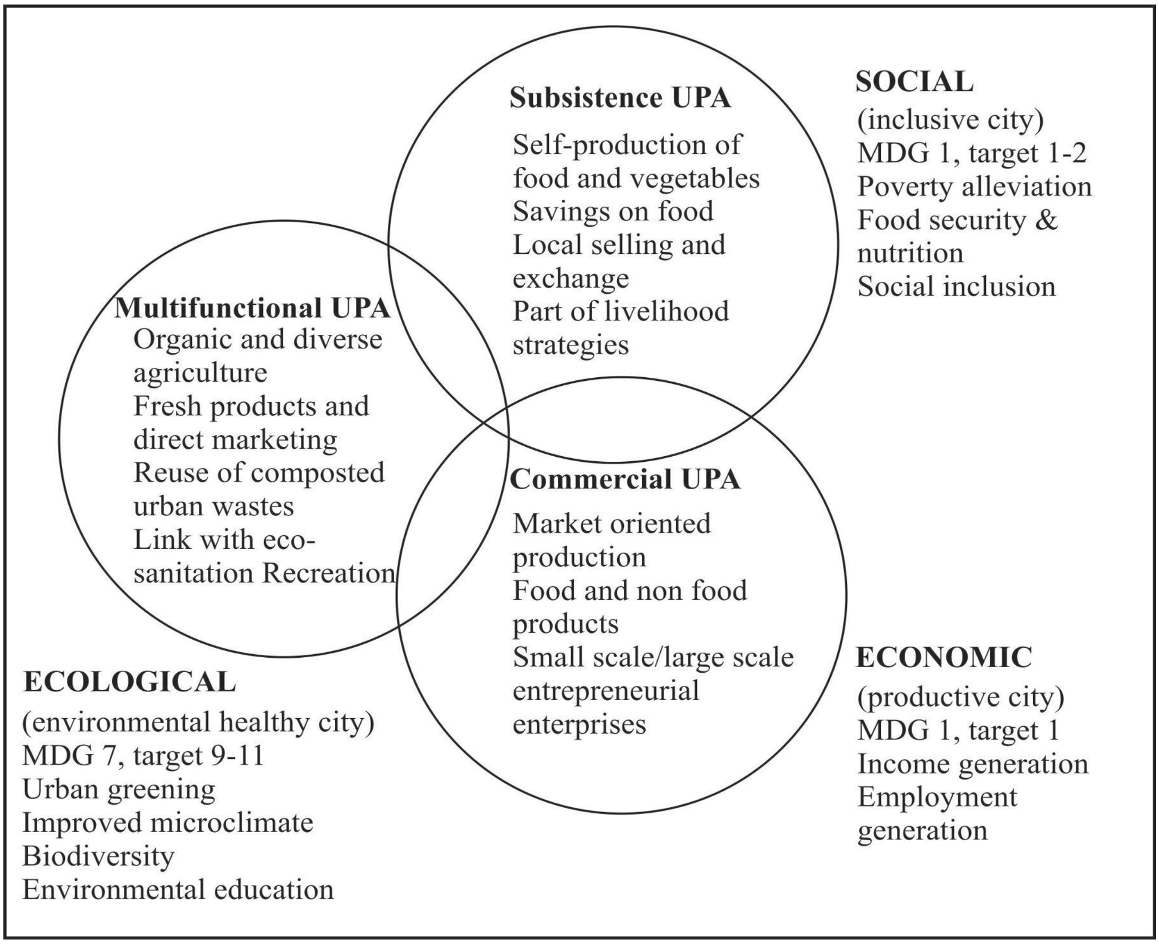

Figure 1 Social, ecological and economic dimensions and various types of urban and peri-urban agriculture (modified after; De Zeeuw et al., 2011).

depending on limited resources including water (Smit and Nasr, 1992). The achievement of food security can be asserted by increasing production, preventing post-harvest losses, improving the distribution network and enabling accessibility of food to poor people. The UPA can potentially fill the hunger gap by enhancing the access to and distribution of food in urban areas (Lee-Smith, 2010). Initially urban agriculture was started as a part of leisure time activity as well as subsistence in world wars; a radical transformation of the objectives of UPA occurred during the early 1980s (Figure 1 and 2). In African countries especially Nigeria (Kano), Zimbabwe (Harare), and Tanzania (Dar-Es-Salaam) UPA became an integral part of the permanent landscape (Smith, 2001; Bryld, 2003). The driving force behind the transformation in UPA towards market oriented production is the increase in urban population

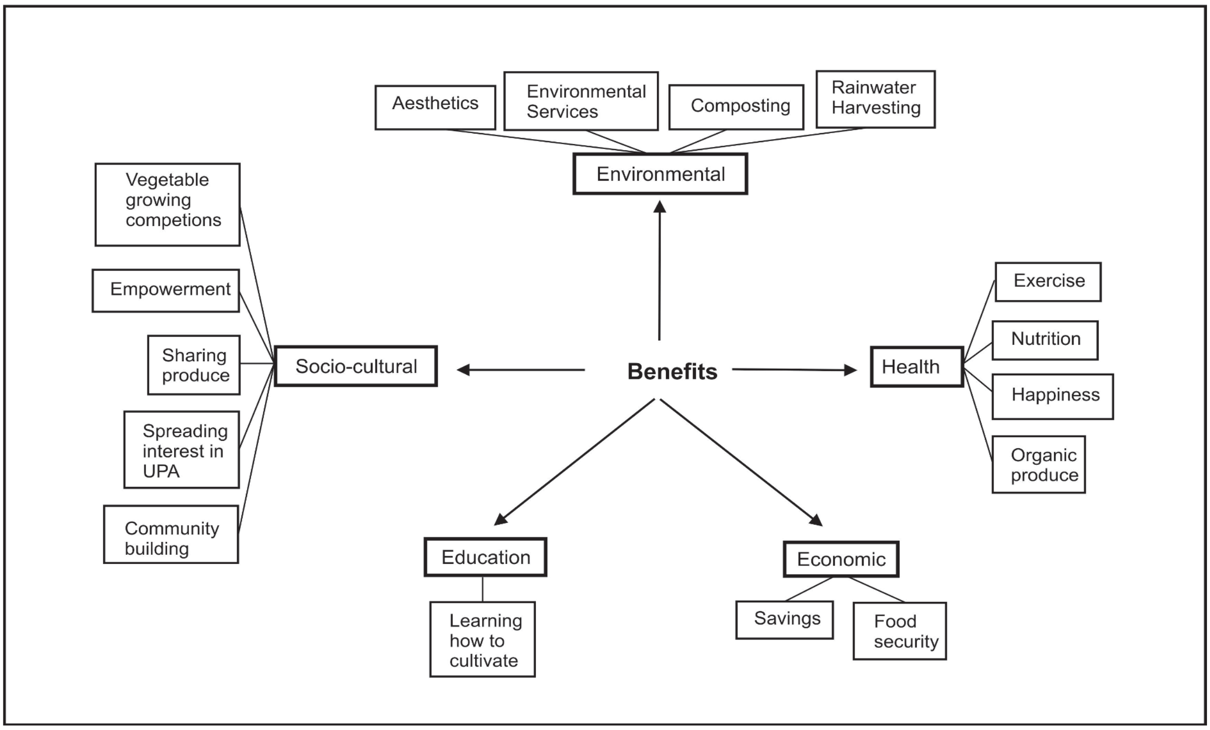

Figure 2 Benefits and services offered by various types of urban and peri-urban agriculture (modified after; Devenish, 2009).

and poverty (Cohen, 2006; Obuobie *et al.*, 2006; Hill *et al.*, 2007; Sinha, 2009; Ward, 2013).

UPA production systems may reduce the ecological foot print of cities and allow for synergies between urban domestic and industrial sectors (Jansen, 1992; Midmore and Jansen, 2003; De Zeeuw *et al.*, 2011). More than 800 million farmers are in involved in UPA production, of which 200 million depend on wastewater for irrigation (UNDP, 1996; Bahri, 2009). The use of non-treated wastewater and industrial pollution make this system much more prone to high level heavy metals and microbial load thereby challenging the quality of urban produce (Diogo *et al.*, 2010; Abdu *et al.*, 2011a; Abdu *et al.*, 2011b; Kiba *et al.*, 2012; Safi and Buerkert, 2012).

Our objectives of the study were (1) to give an overview of the UPA production systems in India which are irrigated with wastewater (2) to compare the status quo of heavy metals present in different locations where UPA is practiced in India.

Methodology

The methodology used in this paper was based on primary and secondary data from various resources. In this paper, we review the current status of UPA production in India using wastewater as an irrigation source. We collected different research articles and books from multiple academic databases. Thus, this paper built partially on our own research work as well as on a literature survey. The negative impacts on environment and health using wastewater were also mentioned. The results were analysed by descriptive statistics using SPSS 12.0 (SPSS Inc., Chicago, IL, USA) and graphs were generated using Sigma plot 7 (Systat Software Inc., Chicago, IL, USA).

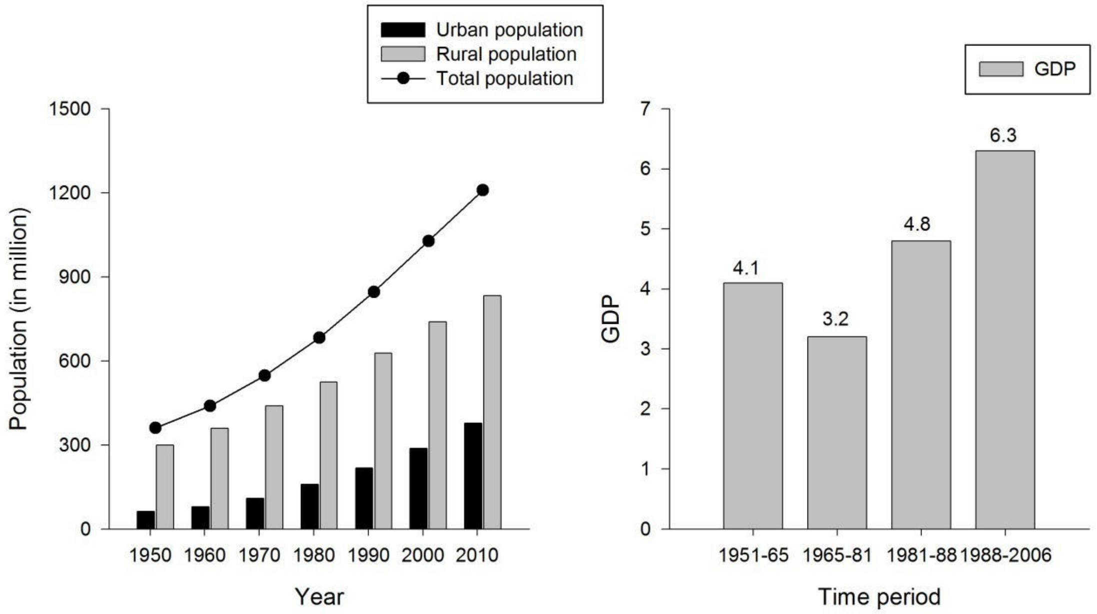

Figure 3 Population growth and Gross Domestic Product (GDP) growth in India from 1950 to the 2000s (after Panagariya, 2008).

Urbanization in India

India is the world's largest democratic nation with a population of 1.2 billion (Figure 3) where one third of the poor still lives below the poverty line of 1 US$ per day (Datt and Ravallion, 2002; Deaton and Dreze, 2002; Census India, 2011). The current growth rate, genie coefficient and multidimensional poverty index of India is 4.0, 36.8 and 0.28 respectively (Krueger, 2008; Panagariya, 2008). In 1950, it was estimated that 82% of the total population lived in rural areas and agriculture contributed 56% of the Gross Domestic Product (GDP). While in 2010, due to rapid urbanization the rural population declined to 70%, the urban population keeps increasing at a faster rate (Panagariya, 2008; Census India, 2011). The major populated metropolitan regions in India (Table 1) include the National Capital Region (NCR), Mumbai Metropolitan Region (MMR), Kolkata Metropolitan Region (KMR), Chennai Metropolitan Region (CMR), Bangalore Metropolitan Region (BMR) and Hyderabad Metropolitan Region (HMR). Based on the above facts, current population growth and relevance of UPA, our research question deals with the safety aspect of wastewater irrigation in UPA production systems in India.

By 2025 India is expected to be the world's most populous country, thus bringing down the land to man ratio even further. The urban population will surpass the rural population in the course of the next decade. Land will become a more scarce resource for the farmers in the peri-urban areas and subsequently villages were transformed to urban areas. India's rate of urbanization is estimated to be about 3.5% per annum (Datt and Ravallion, 2002; Panagariya, 2008). The projection is that by 2020, about 50% of the total population of India will live in urban areas. Population explosion and the migration of people towards urban area create more pressure on food, shelter, water and basic necessities (Cohen, 2006). Migration from rural area to urban area is a common phenomenon in India, where people look for better employment, education, services and financial gain. Transformations in villages, alternative jobs in construction and various industries, poor productivity in agricultural labours seeking better job opportunities and climate change are some key factors triggering the decline of farming activities in rural and peri-urban areas (Sharma and Bhaduri, 2006; Martin, 2010).

It is estimated that Indian cities will generate 70% of the new jobs and 70% of Indian GDP in the year 2030 (McKinsey Global Institute, 2010). Employment and surging growth in Indian cities drove their population to 340 million in 2008 and could reach 590 million by 2030 (Panagariya, 2008). Poverty and a lack of gainful employment in rural areas drive people to the cities for work and livelihood (Bhowmik, 2000). Five states in India will have more than 50% of urban population including Tamil Nadu, Gujarat, Maharashtra, Karnataka and Punjab by 2030 (McKinsey Global Institute, 2010).

UPA production in India

Urban agriculture in India is witnessing a beginning with piecemeal efforts in a few cities. Against the backdrop of tremendous population growth, haphazard and unplanned urbanization, growing food scarcity and increasing fruit and vegetable prices, there is the growing presence of urban agriculture in some form or other in every city. It is used as a resource conserving industry, where waste is converted to resource. It creates a diverse ecology where fruit trees, vegetable plants and fish production co-exist with the built environment of the urban poor, mostly migrants, making an ecologically sustainable scenario. The phenomena usually take place in the low-lying city fringes, which play important roles such as: a) controlling floods b) functioning as a workshop of 'resource conservation industry', where the open loop of thrown away garbage becomes a closed loop by converting it into resources c) supplying food and commodities to the city to keep the metabolism d) providing employment opportunities in the informal sector.

Urban agriculture can be considered one aspect for mitigating food insecurity and malnutrition among urban poor in India. In addition to livelihood opportunities, urban waste management also greatly improved (Gupta and Gangopadhyay, 2013). Usage of

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wastewater in agricultural production systems can significantly provide an uninterrupted supply of resources, especially irrigation water and nutrients which can offer improved crop yields (Bahri, 1999; Kretschmer *et al.*, 2002; Bahri, 2009). The major UPA production centres in India were the six metropolitan cites (Figure 4 and 5).

Wastewater use

Due to the shortage and demand of fresh water, wastewater is often used as a valuable resource to meet the demand. It was estimated that on a global scale about 20 million ha (hectares) of land were irrigated with wastewater (Hamilton *et al.*, 2007). Wastewater reuse in agriculture a) provides an additional source of water, nutrient and organic matter b) reduces the discharge to the surface water c) improve the economic efficiency of investments in wastewater disposal and irrigation (Khouri *et al.*, 1994; Verma and Rakshit, 2010). Wastewater is comprised of domestic effluents, commercial establishments, industrial effluents and urban runoff. The constituents may vary spatially and temporally depending on the climatic conditions (Scott *et al.*, 2004). The most relevant wastewater usage includes a) direct use of untreated wastewater b) direct use of treated wastewater c) indirect use of wastewater (Figure 6 and 7). Use of wastewater for irrigation and aquaculture is considered a part of the informal sector in India and receives less attention from governments (Buechler *et al.*, 2002; Buechler and Devi, 2003; Buechler and Mekala, 2005; Amerasinghe *et al.*, 2013). The majority of wastewater generated in India was taken from industrial effluents. According to Strauss and Blumenthal (1990), 73,000 ha were irrigated with wastewater in India. The majority of wastewater irrigation occurs along rivers adjacent to growing cites especially Delhi, Kolkata, Coimbatore, Hyderabad and Varanasi (Scott *et al.*, 2004).

Wastewater usage in Hyderabad

The seasonal flow pattern of the Musi River has been lost and most of the urban wastewaters drain into the river. Currently these wastewaters were used for growing para grass (*Urochloa mutica*) and paddy (*Oryza sativa*) where fodder grass targets the urban dairy market. Other wastewater irrigated crops include banana, coconut and vegetables with an estimated area of wastewater irrigation around 200 km^2 (Ensink *et al.*, 2005; Van Rooijen *et al.*, 2005). Along the Musi River it was estimated that 2,100 ha land were irrigated with wastewater to cultivate paddy (Mekala *et al.*, 2008; Srinivasan and Reddy, 2009). More than 13 vegetables were also grown under waste water irrigation which includes spinach (*Spinacia oleracea* L.), malabar spinach (*Basella Alba* L.), red amaranth (*Amaranthus cruentus* L.), mint (*Mentha spicata* L.), coriander (*Coriandrum sativum* L.), lady's finger/okra (*Abelmoschus esculentus* L.), taro (*Colocasia esculenta* L.) and common purslane (*Portulaca oleracea* L.). Flower production, especially jasmine (*Jasminium officinale* L.) using wastewater is also reported by Buechler *et al.* (2002).

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Figure 4 Major UPA production systems from India: (top left), Railway Garden (RG) from the Mumbai Metropolitan Region; (top right), RG irrigated with wastewater; (middle left), farmers washing the white radish harvested from RG; (middle right), wastewater lagoon for fish production from Kolkata Metropolitan Area; (bottom left), mustard cultivation using wastewater in Kolkata Metropolitan Area; (bottom right), wastewater irrigation using motor pumps from lagoon in Kolkata Metropolitan Area.

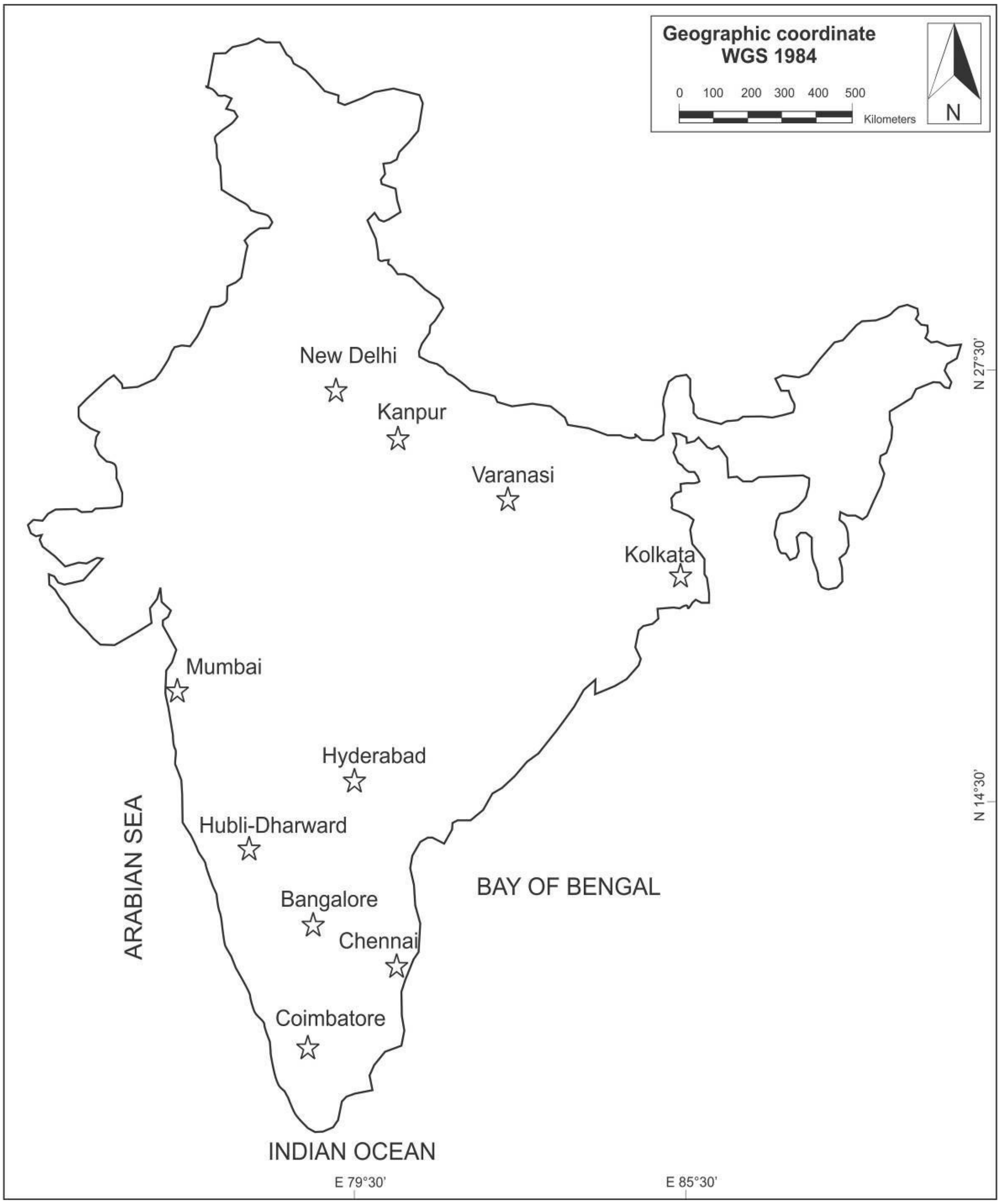

Figure 5 Map of India showing the location of the UPA production areas (marked as star symbol). Source: own illustration.

Wastewater usage in Mumbai Metropolitan Region

In the Mumbai Metropolitan Region (MMR) the Indian Railways plays a major role in UPA production. Under the scheme "Grow more food", the Indian Railway companies has rented since 1975 unutilized land near railway tracks and stations to railway class IV employees and non-railway employees for promoting the cultivation of vegetables and as a part of corporate social responsibility (CSR). In the MMR, about 176 hectare of land were allotted among 282 railway employees who transformed this land to productive railway gardens by growing vegetables such as okra, spinach, red amaranth and taro which were predominantly irrigated with wastewater (Table 2; Vazhacharickal and Buerkert, 2012; Vazhacharickal et al., 2013).

Wastewater usage in Delhi Metropolitan Region

It was estimated that 1,700 ha of land irrigated with wastewater to grow cucurbits (*Cucurbita pepo*), eggplant (*Solanum melongena* L.), okra, coriander in summer and spinach, mustard (*Brassica juncea*), cauliflower (*Brassica oleracea* L.) and cabbage (*Brassica oleracea* var. *capitata*) in the winter across the Delhi metropolitan region (Mekala *et al.*, 2008).

Wastewater usage in Kolkata Metropolitan Region

The east Kolkata sewage fisheries represent the largest single wastewater usage system in aquaculture in the world (Pescod, 1992). It was estimated that 12,800 tonnes of paddy, 6,900 tonnes of fish and 0.7 tonnes of vegetables were produced in this region (Chattopadhyay, 2002; Mukherjee *et al.*, 2013).

Wastewater usage in Hubli-Dharwad

Wastewater irrigated agro-forestry systems were observed in villages near Hubli-Dharward in Karnataka. The tree species include sapodilla (*Manilkara zapota*), guava (*Psidium guajava*), coconut (*Cocos nucifera* L.), mango (*Mangifera indica*), areca nut (*Areca catechu*) and teak (*tectona grandis*). This complex agrosilivultural system also contains neem (*Azadirachta indica*), tamarind (*Tamarindus indica* L.), banana (*Musa acuminata*), pomegrate (*Punica granatum* L.) and mulberry (*Morus alba* L.; Bradford *et al.*, 2003).

Wastewater usage in Kanpur

During 2004 it was estimated that 2,770 farmers were involved in wastewater agriculture stretching to 2,500 ha. About 400 million litres of wastewater were discharged in Kanpur per day (Gupta, 2013).

Wastewater usage in Coimbatore

In Coimbatore the major wastewater irrigation can be seen near Ukkadam with a sewage farm of size 35 ha cultivated with Guinea grass (*Megathyrsus maximus*), para grass, elephant grass (*Pennisetum purpureum*) and coconut (Jeyabaskaran and Sree Ramulu, 1996; Chitdeshwari *et al.*, 2003; Somasundaram, 2003; Malarkodi *et al.*, 2007).

Wastewater usage in Varanasi

In Varanasi it was estimated that 240 million litres of swages were generated. The major vegetables grown were radishes (*Raphanus sativus* L.), turnips (*Brassica rapa* var. *rapa* L.), carrots (*Daucus carota*), tomatoes (*Solanum lycopersicum* L.), cauliflower, eggplant, potatoes (*Solanum tuberosum* L.), cabbage, spinach and coriander which are targeted toward the urban market in Varanasi. The major villages using wastewater irrigation were Dinapur, Khalispur, Kotwa, Kamanli and Shiwar (Ghosh *et al.*, 2012).

Wastewater usage in Chennai

The major crops were millets (*Pennisetum glaucum* L.), sugarcane (*Saccharum* L.) and paddy, (Janakarajan *et al.*, 2010), but the usage of wastewater has not been officially reported by any authors, even though the usage with wastewater is common in peri-urban areas.

Health hazards associated with UPA production using wastewater

Human health risks from wastewater irrigation includes primarily farmers and labourers and secondly consumers. The possible health hazards involve microbial pathogens as well as helminth. In addition the soil and crop contamination of organic and inorganic trace elements were also reported in wastewater irrigation (Ganeshamurthy *et al.*, 2008). Farmers using wastewater irrigation are more prone to helminthes and skin problems than a famer using fresh water. (Trang *et al.*, 2007; Qadir *et al.*, 2010). Continuous irrigation with wastewater may lead to heavy metal accumulation in the soil and their subsequent transfer to the vegetables (Table 3 and 4). Due to the persistent nature of these heavy metals, they may accumulate in vital organs and can cause numerous health disorders.

Concentrations of total Pb (lead) and Cd (cadmium) exceeded the safety thresholds (Table 6) in many vegetables, especially in spinach (3.8 and 1.8 mg kg^{-1}), green amaranth (3.3 and 0.2 mg kg^{-1}), white radish leaves (6.8 and 0.5 mg kg^{-1}), and white radish root (5.7 and 0.2 mg kg^{1}). In all samples analysed Hg (mercury) and Ni (nickel) were below detection limit. The presence of Pb and Cd in plant material may in the long run create health hazards for the consumers. These metals are often accumulated in leafy vegetables and root crops when compared to fruits and seeds. The supply of nutrients in the irrigation water (Figure 8) may leads to ground water leaching which may affect the apparent nutrient usage efficiency of the system.

Management interventions for risk reduction

Human and environmental risk of wastewater usage can be reduced by a set of combined measures. These include a) water quality improvements b) human exposure control c) farm level wastewater and d) harvest and post-harvest interventions (WHO, 2006; Qadir *et al.*, 2010). Improvement in the quality of wastewater can be achieved by combination of primary and secondary treatment. Protective gadgets especially boots and gloves

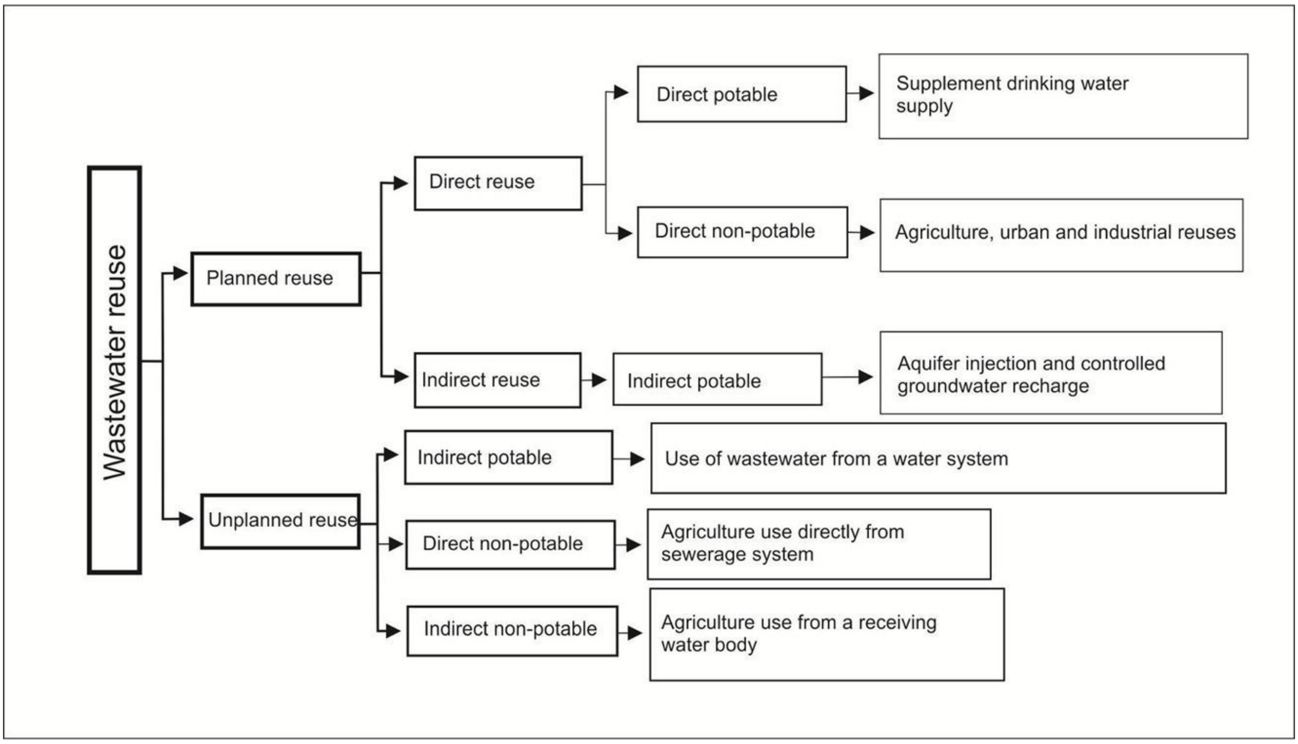

Figure 6 Topology of wastewater usage (adapted from Keremane, 2007).

and changing irrigation methods can also lower the risk. Farm management practices including crop diversification irrigation and manure requirement also a play a vital role. Finally the harvest and post-harvest interventions can also substantially reduce the health risk (Qadir *et al.*, 2010).

Government and public authorities lack the technical and management options to reduce the health risks associated with wastewater usage. Policies should be made to reduce the negative impacts of wastewater usage while supporting its benefits including the source as a valuable nutrient and organic matter. Management of wastewater and proper treatment will substantially reduce the possible health risks. Conducting public awareness programmes will certainly make the farmers and consumers aware of the negative aspects of wastewater irrigation thereby encouraging them to adopt hygienic management practices.

Discussion

The contribution of UPA towards food security and employment opportunities was well appreciated in India. It is unquestionable that the UPA provides access of food to the urban poor at a cheap price. In addition to all these plus points, the usage of non-treated wastewater may impose long term health problem as well as the accumulation of heavy metals in the soils. Heavy metals were reported in various UPA production systems depending on

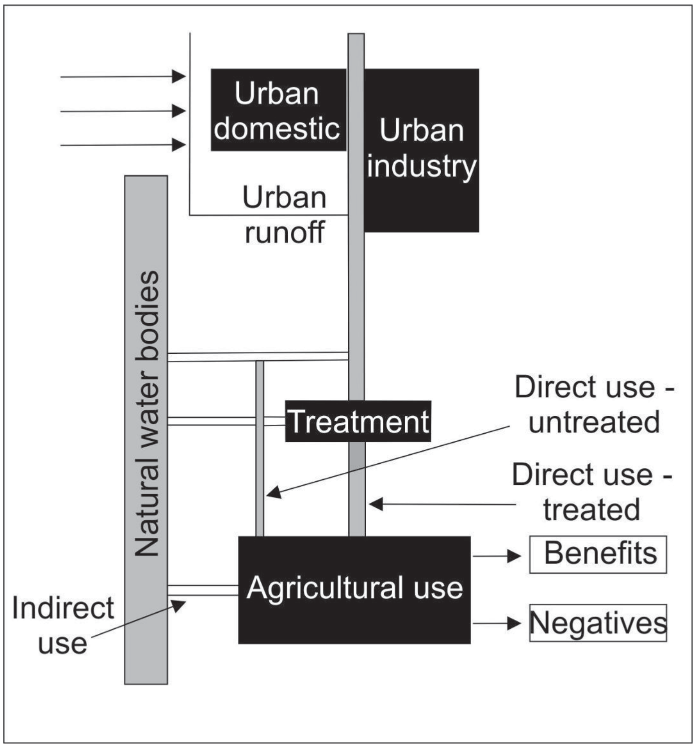

Figure 7 Dimensions of water usage (adapted from Scott *et al.*, 2004).

wastewater as irrigation sources. Heavy metal contaminations in vegetables grown using wastewater were reported in Hubli-Darwad (Hunshal *et al.*, 1997), Varanasi (Ghosh *et al.*, 2012), Hyderabad (Srikanth and Reddy, 1991) and Coimbatore (Malarkodi *et al.*, 2007). Consumption of vegetables with heavy metals may lead to accumulation and its long term use can pose serious health risks to the consumers. Attention is needed for the monitoring of industrial effluents, hygienic practices among farmers as well as the productive use of wastewater for irrigation. A permanent solution to prevent the heavy metals into the food chain seems to be less practicable in the Indian scenario; however, the methods should be adopted to reduce the integration of these heavy metals, particularly through wastewater treatment as well as bioremediation methods.

Conclusions

Ensuring jobs and food security among the urban poor is a major challenge in underdeveloped and developing countries. Urban and peri-urban agriculture is one of the best options to address increasing urban food demand and can complement rural supply chains and reduce ecological foot prints.

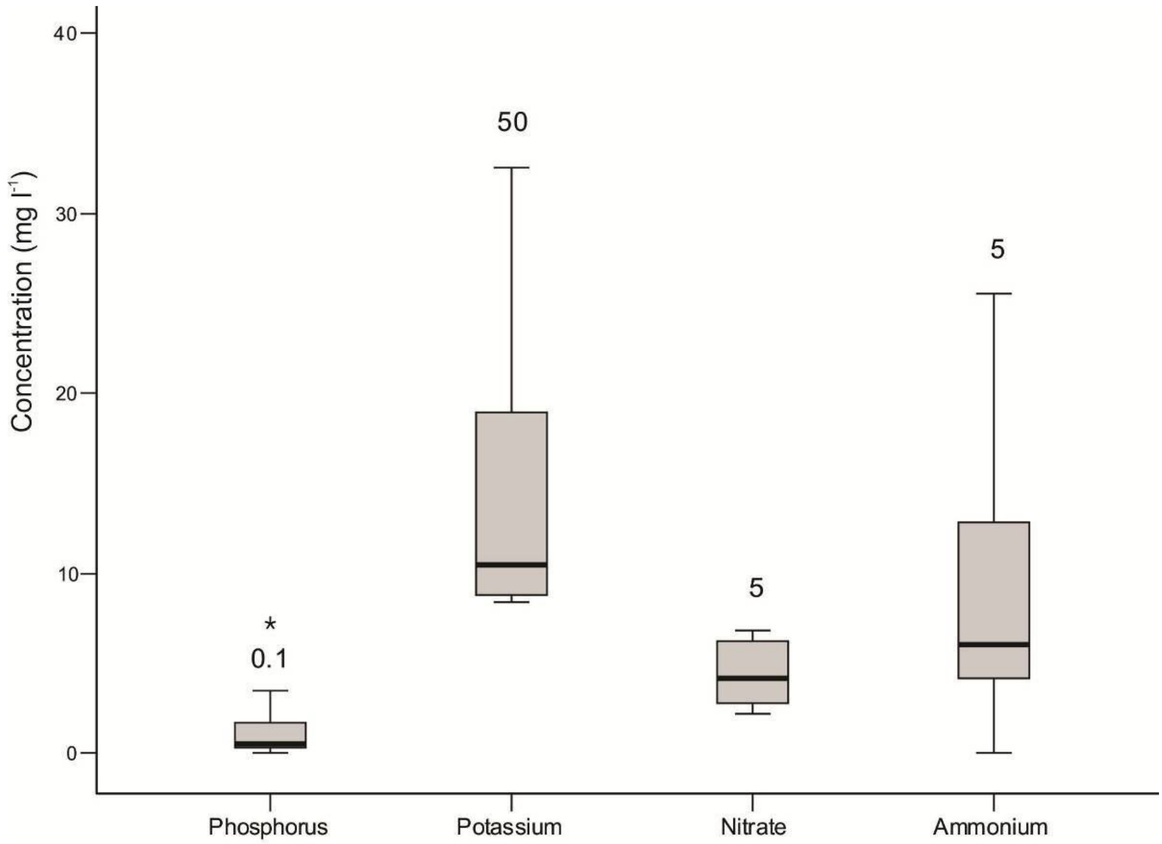

Figure 8 Box plot showing the chemical characteristics of the irrigation water in ten UPA production systems across the Mumbai Metropolitan Region (India) and recommended threshold levels (FAO, 2010) displayed above the whisker.

The growing water demands and release of untreated wastewater pose a big challenge to environmental sustainability. Irrigation with wastewater is a reality and common practice in India. However, the possible health risks associated with them should receive attention from the policy makers and stakeholders. An integrated approach with suitable risk reduction mechanism would improve the efficiency and safety of these UPA production systems which can be called "Good practice urban and peri-urban agriculture".

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Appendix

Rank	Metropolitan area	State/Territory	Governing authority	Area (km²)	Population	Population density (km²)
1	National Capital Region (NCR)	Delhi, Uttar Pradesh, Haryana	Delhi Development Authority (DDA)	1,483	21,753,000	9,340
2	Mumbai Metropolitan Region (MMR)	Maharashtra	Mumbai Metropolitan Region Development Authority (MMRDA)	4,355	20,748,000	4,764
3	Kolkata Metropolitan Area (KMA)	West Bengal	Kolkata Metropolitan Development Authority (KMDA)	1,886	14,617,000	12,883
4	Chennai Metropolitan Area (CMA)	Tamil Nadu	Chennai Metropolitan Development Authority (CMDA)	1,189	8,728,000	5,921
5	Bangalore Metropolitan Area (BMA)	Karnataka	Bangalore Development Authority (BDA)	1,276	9,645,000	7,600
6	Hyderabad Metropolitan Area (HMA)	Andra Pradesh	Hyderabad Metropolitan Development Authority (HMDA)	7,100	7,749,000	7,826

Table 1 Major metropolitan areas in India and their characteristics during the year 2011 (KMDA, 2012).

Serial No	Common name (English)	Local name (Hindi)	Botanical name
1	Lady's finger/Okra	Bhindi	*Abelmoschus esculentus* L
2	Spinach	Palak	*Spinacia oleracea* L
3	Red amaranth	Lal Maat	*Amaranthus cruentus* L
4	Fenugreek	Methi	*Trigonella foenum-graecum* L
5	White radish	Mula	*Rhaphanus sativus* var. *longipinnatus*
6	Malabar spinach	Mayalu	*Basella alba* L
7	Green amaranth	Chawli	*Amaranthus tritis*
8	Sorrel leaves	Ambaadi	*Hibiscus sabdariffa* L
9	Taro	Alu	*Colocasia esculenta* L
10	Dill	Shepu	*Anetthum graveolens* L

Table 2 Vegetables cultivated in UPA railway gardens of the Mumbai Metropolitan Region, India (Vazhacharickal et al., 2013).

Heavy metal *	Mean	SD	Min	Max	Thresholds	
Lead (Pb)	0.03	0.02	0.00	0.06	0.2 †a	0.05 ‡b
Cadmium (Cd)	0.38	1.08	0.00	3.47	0.05 †a	0.003 ‡b
Mercury (Hg)	0.003	0.001	0.001	0.005	0.002 †b	0.006 ‡b

* All values in mg l^{-1}
a Agricultural Standards
b Domestic Standards
† Department of Water Affairs and Forestry (1996), South African Water Quality Guidelines
‡ FAO (2010)

Table 3 Heavy metal concentrations in irrigation water collected from 10 UPA production systems in the Mumbai Metropolitan Region and recommended threshold levels.

Data	Cd	Pb	Cu	Zn	Cr	Ni
	(mg kg-1)					
Mean	0.4	3.8	146	133	429	135
SD	0.4	1.4	54	21	209	72
Max	1.1	6.9	231	161	791	247
Min	0.1	3.3	60	103	114	1.1
Thresholds						
India†	3-6	250-500	135-270	300	na	75-150
EU‡	3	300	140	600	150	20-100
UK‡	3	300	80-200	300	400	50-110
USA‡	20	150	170	1400	na	210

Table 4 Total cadmium (Cd), lead (Pb), copper (Cu), zinc (Zn), chromium (Cr) and nickel (Ni) concentrations in the surface soil (0-20 cm) of seven UPA production systems across the Mumbai Metropolitan Region, India.

Locations	Zn	Cu	Cd	Pb
	(mg kg-1)			
Bangalore	71.8	3.52	0.35	35.2
Kolkata	1300	160	4.0	170
Varanasi	87.9	33.5	2.7	18.3
Coimbatore	397.4	157.1	8.1	175.5
Hyderabad	2.9	4.3	0.4	8.1
PFA standard	300-600	135-270	3-6	25-50

Table 5 Total heavy metal content in soils of various UPA production system across India (modified after; Ganeshamurthy *et al.*, 2008).

Data	Cu	Zn	Cr	Pb	Cd
	(mg kg-1)				
Mean	7	40	4	5	0.6
SD	4	34	4	2	0.7
Max	13	96	11	7	1.8
Min	3	9	1	3	0.1
Safety thresholds					
WHO†	40	50	na	0.3	0.2
India‡	30	50	20	2.5	1.5

Table 6 Concentrations of total copper (Cu), zinc (Zn), chromium (Cr), lead (Pb) and cadmium (Cd) in green amaranth, spinach, white radish and paddy (mg kg^{-1} dry weight) from UPA production systems (n=4) across the Mumbai Metropolitan Region, India.

Pioneer Environmentalist and a Critical Thinker

Prof. Dr. Ernst Ulrich von Weizsäcker

June 25, 2014 is a remarkable day for *Future of Food Journal*. We celebrate the 75th birthday of our senior Editorial Board member Prof. Dr. Ernst Ulrich von Weizsäcker. As a distinguished senior scholar in environmental science, his philosophical, theoretical and practical contributions are significant to academia and society alike, challenging and reconfiguring conventional and mainstream thinking. Prof. Dr. Ernst Ulrich von Weizsäcker was born on 25 June, 1939 in Zürich, Switzerland. He studied Chemistry and Physics and received a Diploma from Hamburg University. He achieved his doctoral degree in Biology at Freiburg University in 1969. In 1972, Prof. Dr. Weizsäcker was appointed Professor for Interdisciplinary Biology at the University of Essen. As the founding president of the University of Kassel, he played a momentous role to give birth to a modern university indebted to the spirit of critical thinking.

He was officiated as the director at the United Nations Centre for Science and Technology for Development. The Wuppertal Institute for Climate, Environment, and Energy, initiated in 1991 by Prof Dr. Weizsäcker, has been considered as one of main research centres in sustainable development and environmental studies. Furthermore, he was appointed as the Dean of Bren School in Bren School of Environmental Science & Management, University of California, United States in 2006.

Among his academic contribution, *New Frontiers in Technology Application: Integration of Emerging and Traditional Technologies* (1983), *Ecological Tax Reform: Policy Proposal for Sustainable Development* (1992), *Earth Politics* (1994), *Factor Four. Doubling Wealth — Halving Resource Use* (1997), *Limits to Privatization – How to avoid too much of a good thing* (2005) and *Factor Five* (2009) can be listed as most influential books. The book *Factor Four, Doubling Wealth — Halving Resource Use* (1997) has been translated into 11 languages such as Chinese, Czech, French, German, Italian, Japanese, Polish, Russian, Spanish and Hungarian. He is the lead author of *Decoupling: Technological Opportunities and Policy Options*, which is compiled by the UNEP International Resource Panel in 2014.

In honour of his international engagement in critical thinking on development and the improvement of society, he was elected as the Co-President of the Club of Rome in 2012. Prof. Dr. Ernst Ulrich von Weizsäcker was elected as a Member of the Bundestag (MdB), the Federal Parliament of Germany, in 1998 and held his seat until 2005. He was appointed chairman of the Environmental Committee in the Federal Parliament of Germany.

In admiration of his international contributions, Prof. Dr. Ernst Ulrich von Weizsäcker was awarded from Duke of Edinburgh the Gold Medal by World Wild Fund For Nature (WWF) International in 1996 and the German Environment Prize in 2008. He was a former president (1988-1991) and he serves as an advisor of the Federation of German Scientist (VDW).

Celebrating valued milestone of his life, a book titled *Ernst Ulrich von Weizsäcker – A Pioneer on Environmental, Climate and Energy Policies*[1] will present his passionate and courageous scholarly contributions. The members of the Editorial Board of *Future of Food: Journal on Food, Agriculture & Society* wish Prof. Dr. Ernst Ulrich von Weizsäcker a great and happy birthday!

[1] For more details on the anniversary publiction, please log in at *http://www.springer.com/environment/environmental+management/book/978-3-319-03661-8*

International Green Week Berlin 2014

A Report by ANA STODDART[*]

It is the first snowy white winter morning and the International Green Week seems to lighten up Berlin and give a warm welcome to the locals at the Messe (Showroom). The Green Week and its Agricultural Policy meetings (Global Forum for Food and Agriculture) dates back to 1926; nowadays this modern international Fair is becoming one of the world's largest fair for food, agriculture and gardening. The trade show is highly oriented to consumers with over 20 exhibiting halls displaying live animals, flowers and natural farm products as well as offering visitors with a wide range of food, products and entertaining activities.

A walk through the fair allows you to enrich your knowledge on different agricultural and rural topics and at the same time gain a better palate on ethnic and national (German) food and beverages. One of my first stops was at a small rice-producing establishment "*ETAGUI*" from Republic of Guinea that came to Berlin to seek for a trade partner and start exporting into the EU.

In a following hall, I came across the Moroccan Pavilion and learned about "*Aknari Jabal Ait Baarmrane*" *(image on the left)* innovations on packaging and marketing ancient traditional products such as cactus pickle and powder as well as its anti-age Prickly Pear oil. Further on, I visited a Dutch Flower Stand *(image below)* that has been coming to the Green Week for the past ten years. They considered the fair to be a good promotional outlet and market place for Horticulture.

Every hall has something exciting and diverse to amuse you; you feel like touring all Germany through its regional cuisine while enjoying a live performance, connecting with nature and colourful flowered gardens or letting you imagination travel abroad to exotic destinations.

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GFP stall. Photos by *Ana Stoddart*

A definite highlight in the Green Week was to learn about "*The German Federation of Private Plant Breeders (GFT)*" interesting projects on agricultural and horticultural crop breeding for food, feed and in some cases even Bioenergy.

These non-profit associations, which several of its members are small and medium scale German farmers, carries out research programs by highly qualified professionals and scientific institutions to provide competitive and suitable answers to breeders needs.

All in all, the International Green Week Berlin is most definitely a place to awake your senses and explore worldwide gastronomy, gain insides into the field of agriculture and become dazzled by the impressive beauty of its horticulture section.

For further information please visit:

International Green Week Berlin: *http://www.gruenewoche.de/en*

German Federation of Private Plant Breeders (GFP): *http://www.bdp-online.de/deD/GFP*

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Summer Camp 2014

AGROECOLOGY, SMALL-SCALE FARMING AND REGIONAL DEVELOPMENT


Photo credit: FB 11 Uni-Kassel

The Department of Organic Food Quality and Food Culture, University of Kassel, Germany offers a sommer camp in the Heide region (Natendorf, Uelzen) in Germany. This will be held from 26th of July to 2nd of August in 2014. Young scientists from any level are kindly invited to join the camp. Although inter-national participants are highly welcomed, the camp will be held in German, thus requiring minimum level B1 of German language skills.

The camp addresses five thematic areas in five days:

1. Sustainable cities and villages: self-sufficient neighbourhoods
2. Land grabbing at village scale: messing up village livelihood
3. Land rent issue: no room for youngers
4. Bio-diversity at small-scale farming
5. Farming ethics

For more information and registration please visit: ***http://www.summercampfofj.org/***

Water-Food-Energy Nexus

Prof. Dr. Uschi Eid is a pioneer practitioner and scholar in water resource management and sanitary services. She has been engaging in and contributing to several international and national projects which focus on enhancing humanitarian basic services in water access and sanitary services. In admiration to her excellent contribution to the understanding, development, management and protection of groundwater resources internationally, she has been awarded Distinguished Associate Award the International Association of Hydrogeologists (IAH). From 2009, Prof. Dr. Uschi Eid is serving as an Emeritus – Honorary Professor in the University of Osnabruck, Germany. Her research specialty in the university is sustainable water supply and waste water treatment. Currently, she serves as the Vice-Chair of the United Nations Secretary General's Advisory Board on Water and Sanitation (UNSGAB). She has given an interview entitled *Water has never been recognized in its importance for economical development and poverty reduction* to the Water-Energy-Food Nexus in 2011. In this video, Prof. Dr. Uschi Eid emphasizes the necessity to have "nexus understating, and implementation" of water, food and energy.

The video link : *http://tinyurl.com/o3mru35*

Our special thanks to the Water-Energy-Food Nexus.

Reference

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Reports & Analyses

Water for Food: *Feeding what?*

A Comparative Analysis of Egyptian and Israeli National Water Policies toward Water in Agricultural Production

Rebecca L. Farnum *

Submitted 29 January 2014; Published 10 June 2014

Key Findings:

- "Water for food" is not necessarily synonymous with "water for food security"
- Countries with similar geological conditions face very different geopolitical realities; national water policies and agricultural motivations reflect this
- Water policies and research should seek to understand "water for food" and its connections with economics, the environment, and securities more broadly

Keywords: *water security, Egypt, Israel, water policy, agriculture*

Purpose of and Motivation for Brief

Agriculture accounts for 70% of the world's "blue" freshwater use. Understanding how and why this amount of water is allocated for agricultural production is critical in properly managing water resources.

This policy brief will examine how water for food is understood and utilised in national water policies. Using comparative analysis with Egyptian and Israeli case studies, the brief will explore how different geopolitical realities can create drastically different motivations for agricultural water allotments.

Egypt and Israel were selected as case studies for geopolitical considerations. Both are arid or semi-arid, yet devote of a great proportion of national water resources to for agriculture. Each is a downstream riparian but also a regional hegemon. However, the states have drastically different national cultures and priorities. Israel's status as a regional "outcast" in many ways and the recent political turbulence in Egypt – motivated partially by food issues – make the countries particularly interesting for study.

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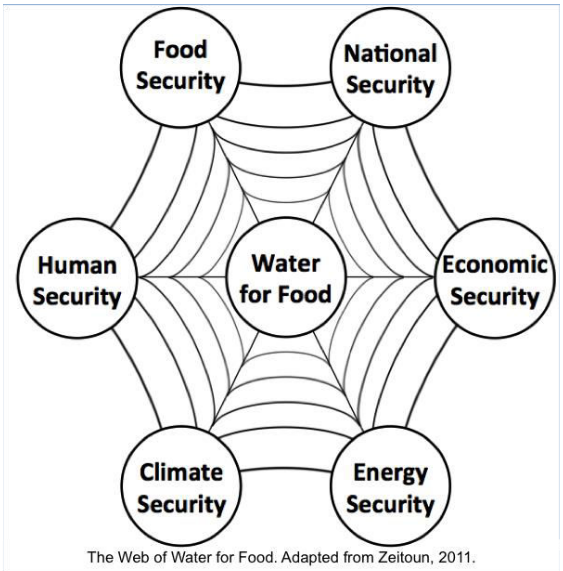
The Web of Water Security

Connections between water, food, energy, and climate are increasingly highlighted in academic research and policymaking. A number of nexuses have arisen in discourses surrounding these issues, the most popular of which is the "Water-Energy-Food Nexus", a concept taken up by numerous think tanks, environmental organisations, international bodies, and governments. More recently, Mark Zeitoun (2011) has suggested a "Global Web of National Water Security", a conceptual tool meant to draw attention to the strong but often unrecognized links between biophysical and social processes surrounding water resources. Zeitoun's web places "water security" at the centre with six connected spokes: national security, water resources security, food security, energy security, climate security, and human/community security.



The Web of Water for Food. Adapted from Zeitoun, 2011.

The Web of Water for Food

This policy brief builds on Zeitoun's web, making the water-food linkage the centre of its own web. The "Water for Food Web" suggests that agricultural water is not necessarily water meant primarily for food as food itself. Instead, national policies around water and agriculture build on a variety of motivations and uses of agricultural production and food products.

- **National Security**. Water and agricultural development have strong ties to nation building. Food production may reduce dependence on external actors and promote internal stability.
- **Economic Security**. Agricultural products may be used in trade. Agricultural sectors can grow local economies and industries. Internal food production may improve resilience to global food price shocks.
- **Energy Security**. Crops may be used for biofuels. Food production may free up money previously spent on food for oil, natural gas, etc.
- **Climate Security**. Agricultural development may increase adaptation possibilities and teach countries to better manage water. Internal production may protect against or make a country more susceptible to climate shocks.
- **Human Security**. Food may be meant to feed people for their own sake. Agricultural production may provide local jobs.
- **Food Security**. Food production may be meant "simply" for food security. But whether food security matters more for urban elites or rural populations and for the sake of individuals or the nation is not always clear.

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Egyptian and Israeli National Water Policies

Current Egyptian policies are muddled by government instability; research reflecting on previous policies may thus be particularly relevant in informing possible future steps. This brief is based on the 2005 "Integrated Water Resources Management Plan" and "Water for the Future: National Water Resources Plan 2017", the latter of which was supported by the Dutch Government. Stated major concerns are water for people; water for food production; water for industry, services, and employment; develop-ping a strong institutional framework; quality, supply, and demand management; protection and restoration of vital ecosystems; and cooperation with Nile Basin countries.

The State of Israel has a nationalised water sector. This brief is based on the 2002 "Transitional Master Plan for Water Sector Development in the Period 2002-2010" and 2011 "Long-Term Master Plan for the National Water Sector", which focus on action in uncertain conditions; system management; consumption management; water and agriculture; urban water systems; improving institutional-organisational structures; quantities and qualities of water; minimising harm to ecological system services; and balancing economic, social, environmental considerations.

The word clouds above highlight the most commonly used words in Egyptian and Israeli National Water Policies, illustrating the two states' different approaches to and priorities in water management. "Agriculture" and "nature" both appear in Israel's; "land" and "agricultural" are relevant keywords for Egypt. "Desalination", "wastewater", and "sewage" are prominent in Israel's,, while "environmental" appears more prominently in Egypt's.

Word cloud ("water" removed)generated from the Egyptian Integrated Water Resources Management Plan, 2005.

Word cloud ("water" removed) generated from the Israeli Long-Term Master Plan for the National Water Sector, 2011.

These word clouds shed light on national-level discourses around water-based resources and indicate the primary motivating factors driving water policies.

Water for Food in Egypt and Israel

While increasing populations and rising demands are the major concern in both countries' national water policies, Egypt and Israel heavily prioritise agricultural development, working to ensure adequate water resources for these sectors. In Egypt, agriculture regularly accounts for more than 80% of its freshwater use. Israel's "Long-Term Master Plan" explicitly states that, once the water sector has stabilised, "the amount of water for agriculture will not be limited and will fully match the needs of the sector's development" (State of Israel 2011: 44). But the two states' motivations for allocating water to their agricultural sectors vary. These motivations can be explored using the "Water for Food Web".

At a Glance: Egyptian and Israeli Agricultural Water

	Egypt	Israel
Population (2011)[1]	82,536,770	7,765,700
GDP (billion current USD, 2011)[1]	229.5	242.9
GDP per capita (current USD, 2011)[1]	2,780.8	3,1282.3
Agricultural sector value (per cent total GDP)[2]	14.7	2.5
Employment in agricultural (per cent total employment, 2008)[1]	31.6	1.7
Agricultural land (% total land area, 2009)[1]	3.7	24.1
Permanent crop land (% total land area, 2009)[1]	0.8	3.6
Renewable internal freshwater resources (billion cubic meters, 2011)[1]	1.8	0.8
Renewable internal freshwater resources per capita (cubic meters, 2011)[1]	21.8	96.6
Annual agricultural freshwater withdrawals (% of total freshwater withdrawal, 2011)[1]	86.4	57.8

1. *World Bank*; 2. *CIA World Factbook*

Water for Food…

…for National Security

Where on the web? Linkages between water for food and securities in Egyptian and Israeli national policies.

	Egypt	Israel
National Security	2	3
Economic Security	2	2
Energy Security	0	1
Climate Security	1	1
Human Security	2	2
Food Security	3	2

Above: 3=strongest; 1=weakest; 0=no link.

Egyptian national security has recently been rather shaken by protest and the overthrow of President Hosni Mubarak. National unrest in the past decade has been motivated partially by global food price spikes over grain, a staple of the Cairene diet. The Egyptian government has since prioritised food self-sufficiency to protect national security against global shocks and has made multiple statements on the need to expand agriculture through irrigation.

Israeli policy documents regularly call agriculture development a "national objective". "Making the desert bloom" was central to Zionist policy. Agricultural success was seen as a way to legitimise the Jewish claim to the land.

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The state continues to employ its technical expertise in irrigation and water efficiency technologies for diplomatic relations. In this way, water for food has been water for nation building more than water for food itself.

...for Economic Security

Egypt's IWRM Plan recognises that agriculture is a "major economic activity in Egypt", accounting for nearly 15% of its GDP. Egypt has been more susceptible than most countries to food price shocks; internal food production is thus partially a mechanism for ensuring economic resilience.

Israeli agricultural produce is marketed throughout Europe and is one of the country's links to countries, something sorely needed for a country unrecognised by many of its neighbours. Israeli policies of agricultural water pricing promote economic sustainability for the sector.

...for Energy Security

Egyptian national water policies say virtually nothing about the link between water for food and energy. For Israel, energy is one of the few issues present in this web that does not come under the direct control of the National Water Authority. A great deal of energy is used in water for food: Drip irrigation and other agricultural technologies are energy-intensive.

...for Climate Security

In Egypt, food industries are one of the major contributors to water pollution. Water for food is thus considered by the state as a climate security issue primarily through the lens of environmental sustainability concerns, and the link between water for food and climate security is a negative one.

In Israel, the bulk of the water used in agriculture is marginal water from brackish sources. Israeli policy documents also speak of the need for water to help preserve the land's fertility. For this country, then, the water for food-climate link is a more positive one.

...for Human Security

Egyptian water policies consider rising populations and improved standards of living, indicating that water for food is considered, at least partially, an issue of human security. Policy documents also speak of the desire to improve farmers' incomes, raising another consideration in water for food. Israeli documents discuss the need to care for rural communities. Population growth, primarily from immigration influxes, is seriously considered.

...for Food Security

Egyptian water policy documents explicitly mention "food security" as often as they do "water security"; indeed, food security is listed as the first challenge "facing the Government of Egypt as pertaining to water resources management" (Arab Republic of Egypt 2005a: 19). Food security is also stated explicitly in Israeli documents as a major policy motivation, but the state is richer and thus more able to depend on food imports if needed.

The links between water for food and food security are obvious in many ways, but consideration is needed of the myriad number of ways states employ "food security". Food security for whom and to which ends?

Conclusions and Recommendations:

- Agricultural water can contribute more than food to a state's national security.
- States facing different geopolitical conditions may have different motivations that lead to similar

policy actions (e.g., Egypt and Israel both prioritise water for their agricultural sectors but for different reasons).

- Policymakers should understand and act on the ways agriculture and food production impact other sectors. In particular:

- The Egyptian and Israeli governments should better incorporate issues of energy and climate security in their national water policies.

- Governments should consider the *negative* impacts of agricultural water on the six securities of the "Water for Food Web" as well as the positive.

- Researchers must consider the nuances of states' motivations in agricultural water allotments.

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Reports & Analyses

From Market- to Development Orientation – The Trade Aspect of Food Security and Agriculture

What Nexus Foundation is engaging in Geneva?

NIKOLAI FUCHS *

Submitted 15 April 2014; Published 10 June 2014

Abstract

Trade rules are suggested to be one of the reasons for the hunger in the world and environmental damage. As current trade rules encourage market orientation and therefore specialization and industrialization of agriculture, which has as side effects rural hunger and environmental damage, there is room for improvement in the international trade regime. One main finding of Nexus Foundations' work in Geneva is a possible new orientation for agricultural and food markets – an orientation on development, rather than purely on markets. This development orientation consists of several elements from development of soil fertility to local markets and consumer relatedness. Since the Bali Ministerial in 2013, the WTO has set up a four year work programme on the issue of food security related to food reserves. This opens the chance to discuss broader food security issues in the realm of trade negotiations.

Keywords: *Trade rules; Food security; Environmental damage; Market orientation; Development orientation*

Introduction

There are many reasons for the hunger in the world. Current international trade rules are suggested to be one of them (Friel and Lichacz 2010). In the wish to help to fulfil the Millennium Development Goals (MDGs), especially MDG one (halving the number of the poor and hungry till 2015) (United Nations, MDGs) one could be tempted to go where the trade rules are made – the World Trade Organization (WTO), and, besides, the United Nations Conference on Trade and Develop-ment (UNCTAD), both situated in Geneva, Switzerland. That is what Nexus Foundation did, when being founded as a think tank and civil society organization (CSO) in 2010. There are quite a few non governmental organizations (NGOs) and CSOs in Geneva (around 250, Schweizerische Eidgenossenschaft), but only very few in respect to agriculture and trade.

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In fact, in 2010 the NGO „3D“ (3D – Trade – Human Rights – Equitable Economy) closed its door, and, even more importantly, the Institute for Agriculture and Trade Policy (IATP) shut down its Geneva-office in summer 2011. Since 2008 the hope had more and more diminished, that the WTO Doha Round would ever come to an end (Maier, 2013). NGOs and CSOs, mainly living on donations, can hardly address themes and issues, where there is no progress over years.

Still the hunger issue remains a burning issue, also in respect to trade. Solutions are dearly needed and new efforts have to be made, to finally come to terms with the trade issue of food security and agriculture. That is, why Nexus Foundation still made its way to Geneva. The presented paper first addresses the agricultural and food security issue in the WTO and then presents the main findings and alternative proposals for a possible future trade prospect.

Agriculture and food security in the WTO

When the American Congress in 1947 dismissed the founding of the International Trade Organization (ITO) as a third Bretton Woods Organization besides World Bank and International Monetary Fund (IWF), it was mainly because of agriculture (McMahon 2006). The United States wanted to protect their agricultural sector. So only the General Agreement on Trade and Tariffs (GATT) came into force, an institution focussed on industrial goods and services, but without agriculture.

It took nearly 40 years, till GATT officially included agriculture again, with the Uruguay Round in 1986. Since then, a special Agreement on Agriculture (AoA) is part of the trade framework, as well in the World Trade Organization WTO founded in 1995, and its newest round, the Doha Round, having started in 2001 (McMahon 2011).

Food security was dealt with as a non-trade-concern since Uruguay, which should be respected, but which would not be part of the trade negotiations (McMahon 2006).

Only with the Bali Ministerial Decision of December 2013, food security became an official issue at the WTO for the first time. The exemption for India, to be allowed to purchase specific staples locally for national food reserves takes food security concerns into account.

With Bali and this exemption, the WTO started a four year work programme in the search for permanent solutions of comparable issues to that of India (WTO, Bali Decisions). So now would be the time, to invest in concepts on longer term solutions for food security and agriculture in international trade terms, a task as well for civil society and academia. Nexus Foundation and others are currently taking up this task to work on and formulate constructive proposals for the food security issue in the WTO.

The main findings about trade rules, food security and the environment

Nexus Foundation, being mainly a think tank, came after three years of extensive work to the following observations, resp. findings (a rough and a bit simplified picture):

Current international trade rules are getting increasingly liberalized; the more countries are gaining membership in the WTO – 159 in 2014. This also applies to the agricultural trade, being dealt with in the WTO Agreement on Agriculture (AoA). At least since agriculture became part of the negotiations when the Uruguay Round started in 1986, agricultural goods are, although dealt with specifically in the AoA, trade items in the negotiations as any other goods and services. Especially agricultural exporters want the international agricultural markets liberalized in turn for opening their borders to other goods and services. Again in turn, exporting countries of other goods and services are forced in the 'give and take' attitude of trade negotiations to open up their agricultural markets.

What would be the problem with liberalized agricultural markets?

Liberalization means foremost „market orientation", which, in turn, means opening the sector for more competition. Competitive markets tend to force their actors to more efficient production, which, in turn, means specialization and industrialization (United Nations, 2014). But specialization and industrialization for agriculture means mostly monocropping (or industrial animal holdings). Agricultural monocrop plantages generally offer, for untrained labourers, only seasonal, and often precarious jobs, with little development perspectives (Sinaga, 2013). Besides, the environmental impact of monocropping is high (Altieri, 2009). In all three areas, where civilization has overstepped the planetary boundaries already – climate change, biodiversity loss and nitrogen load (Rockström et al., 2009) – there is a strong connection with industrialized agriculture. After all, mass production aims in respect to food security to serve the *availability* of food, but is not taking enough into account *accessibility* and *adequacy* (Gualitieri, 2013).

Liberalized trade rules tend as well to serve the „big few"(international corporations, Ishii-Eitemann 2013), whereas smaller producers have to re-organize or disappear. Liberalized trade rules help to make food cheaper, which is mostly good news for urban dwellers, and, as well, for net food buyers in rural areas. But it is not so good news for rural small scale farmers, who live on selling their products. They can hardly compete with – often subsidized – cheap imported food from industrial farming (Ching and Khor, 2013). Most of the hungry live in rural areas (FAO, 2012), many of them being small scale farmers. If they can't sell anything, they even can't buy the cheap food which is imported. Liberalized trade rules give so far no answer to the hunger question of the rural dwellers, and as well no answer to the challenging environmental problems. Social safety nets, often called on to compensate trade liberalization effects (McMahon 2006) are too often flimsy and thin. And as long as externalities of industrialized production are not internalized, the environmental problems remain more or less unsolved.

The core issue – which orientation for agricultural and food markets ?

To address the hunger and environmental issues in respect to trade, in accordance to the respective needs, the question arises, whether the current orientation for trade in agricultural and food markets could be re-adjusted.

At the heart of the AoA is the statement, that agricultural markets should be „fair and market oriented". Market orientation, which is often read as „export orientation", has the above mentioned effect on industries – the tendency to specialization and industrialization, in order to best yield the comparative advantage. But this tendency, which might be good with any other, not nature related industry, is problematic in respect to agriculture. Agriculture is different to other industries, in several aspects: agriculture is bound to the land, agricultures specialization potential is limited due to its nature relatedness, agricultural markets are extremely exposed to price volatility and agricultural goods (food) are essential to people (right to food). Besides, food being not just calories, it should be safe and it is strongly correlated to trust (Fuchs, 2013). Due to this agricultural specificity agricultural and food markets might need a different orientation than „market orientation". Olivier de Schutter, UN Special Rapporteur on the right to food, argues in his final report to the Human Rights Council in March 2014 (United Nations, 2014), where he draws the conclusion from his six-year mandate, that export-led agriculture has led to increased rural poverty (Paras 23/24), to markets, where luxury tastes compete with basic needs (Para 23) and to environmental harm (Para 6). If the right to food shall be fulfilled and the planetary boundaries shall be kept, agricultural markets obviously need a different orientation (he calls for a new paradigm focused on well-being, resilience and sustainability).

Having dealt with the issue for quite a while and having thought it all over again, from Nexus Foundation's point of view agricultural and food markets need not a market -, but a *development* orientation. This development orientation would consist of the following elements:

Development of soil fertility

In order to provide enough food for all, to keep the scarce resource 'water' in the soil, to be resilient to climate shocks and to store carbon, humus content of soils should increase (Müller and Gattinger 2013).

Development of (local) seed exchange systems

In order to keep adaptability to ever faster changing conditions seed resources should be able to develop. This can happen through community seed banks and seed fairs, and community registers of peasant varieties (see recommendations by the Special Rapporteur on food (A/HRC/25/57, Annex A, 2 d.)

Development of (agro) biodiversity

(Agro)Biodiversity is extremely important in respect to sustainable food systems and for resilience to climate change. Not only should the much required halt of loss of biodiversity be the aim, but enhancement and up-scaling (United Nations, FABPs).

Development of ecological intensification

In order to provide enough food for all, agriculture working with nature has to be intensified. Agroecological approaches have to be developed to bring higher and more stable yields. The System of Rice Intensification (SRI) is a good example of this approach (Uphoff, 2011).

Rural development

Food systems should work everywhere and serve the most in need. As most of the hungry live in rural areas, especially rural areas have to be developed (Withanachchi, Köpke and Frettsome, 2013, Weerasekara, 2013).

Development oriented nutrition and diets

As the UN committee on Economic, Social and Cultural Rights in its general comment on the right to adequate food states "...each person should have access to a diet that as a whole contains a mix of nutrients for physical and mental growth, development and maintenance, and physical activity that are in compliance with human physiological needs at all stages throughout the life cycle and according to gender and occupation " (UNCESCR, 1999).

Development of sustainable agricultural and food markets

If market orientation, then, in respect to food, to local markets. Do people at any place have access to adequate and affordable food from sustainably managed agricultural and processing sources? Can people know where their food comes from? Along these lines agricultural and food markets should be developed (Fuchs and Hoffmann, 2013).

This *development orientation* would give a framework for agricultural (and trade) practices, whether they deliver on the above mentioned items:

Does this agricultural and food system

- keep or enhance soil fertility?
- provide incentives for farmers to invest in breeding and development of their agricultural resources?
- keep or enhance (agro)biodiversity?
- develop ecological intensification?
- foster rural development?
- keep or increase the nutritional content of food and enhances nutritional diets?
- strengthen the connection of people with their food?

Observation shows, that the closer and the more direct the market relations, the more diverse agriculture will be. Agricultural markets seem to be closely linked to trust, - consumers increasingly want to know, where their food comes from. Localization is an important trend in the 21st Century (World Bank, 1999). Global value chains with many intermediate steps, as frequent food scandals show, are risky in this respect. Agricultural and food markets seem to be of regional/local nature. Therefore the formula for agricultural and food markets could be „regional/local is first choice". Trade would have the role to complement local markets (Fuchs and Hoffmann 2013).

"Protection" is not the answer

In order to fulfil the above mentioned items of „development orientation"one could be tempted to call for more protection of agricultural and food markets. Despite the fact, that western countries protected and developed their agricultural industries before opening them for liberalization, and „firewalls" are still needed against dumping and infant industries sometimes need protection, protection of agricultural and food markets are medium term not the solution. Protected markets always tend to breed inefficiencies.

Food Sovereignty contextualized

What might instead be relevant is the acceptance of specific forms of food sovereignty. That could be, on the one hand, a preference of local production in public procurement schemes, or on specific qualities like organic food. That could be, on the other hand, any civil society appointments on the food system, which are transparent and agreed upon in a democratic manner. People should have the right to decide upon their food system, but, perhaps most importantly as a rule, as long as the decisions consist of conscious preferences, and not of systematic exclusions on other food offers.

The next steps

As the WTO has decided upon a four year work programme on the food reserves issue, it is now time to work on alternative proposals. But besides the WTO work programme, the overall framework on food security, agriculture and trade is still to be optimized. All in all, from Nexus Foundation's perspective, an overhaul of the WTO agreement on agriculture – to be signposting to any other regional or bilateral free trade agreement – in the above mentioned development orientation (or else) is required.

Currently there are two working groups which are related to these tasks: The QUNO working group on trade and investment (QUNO, 2014) and a UNCTAD task force, where Nexus Foundation is involved in various ways. Both working groups are committed to the above mentioned tasks. Besides this engagement, Nexus Foundation is allied to a civil society working group led by IATP on food reserves, which gave a workshop with Nexus Foundation as co-organizer at the 2013 WTO Public Forum on food reserves. This workshop was well attended, as well from some of the main actors in Bali like India and Australia. Besides, Nexus Foundation is laying down its main findings in articles and communicates them in lectures, workshops, WTO public fora and UNCTAD public symposiums (see homepage www.nexus-foundation.net). Nexus Foundation is as well engaged in representing the SEKEM Group in the core advisory group of the UN Global Conduct Food and Agricultural Business Principles initiative (United Nations, FABPs).

Medium term there is the hope, that some member or members group (the Group of Developing Countries G-33?) of the WTO table a new proposal for agricultural trade rules, which contains an improved trade contribution to reduce hunger and at the same time takes care of the environment. The WTO four year working programme on food reserves offers a first chance.

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Report - Analysis

Water for Food: International Narratives Sidelining Alternative Views

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Introduction

Despite extraordinary advances in science and information technology, vast numbers of people across the globe still lack access to water for agriculture, other livelihoods, and domestic uses. In recent decades numerous global organisations (both inter-governmental and non-governmental) have claimed to represent the views and needs of the world's water users and/or have posed to present science-based solutions to agricultural problems. These organisations present their work by means of hegemonic discourse. Hegemonic is used to describe the way their discourses are presented as authentic, valid, common sense and rational; to the extent that other perspectives are side-lined or marginalised. This argument relates to the two contradictory positions that recur in contemporary neoliberal capitalism: trade-led and competitive (race-to-the-bottom) economic growth on the one hand, and attempts toregulate the environmental impacts of economic growth by states and global institutions on the other (Peet and Watts, 2004). Power and control over resources is increasingly unequally distributed and clustered at centres, while economic capital is largely put to work for the production of food and goods for urban consumers, side-lining rurally-situated subsistence communities (ibid.). Global institutions seek to relieve, via conscious and less-conscious strategies, the political and economic tensions between economic growth and environmental degradation.

The 'global water crisis': abstract notions of water *and* population serving to depoliticise

The discourses propounded by inter-governmental and international institutions change subtly over time.

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However the message remains consistent: we face a global water crisis, and poor countries and poor people will suffer the most and thus must change their ways to adapt to the crisis. The well-to-do and affluent are not told that they must change their behaviour.

The discourse of the 'global water crisis' emerged only towards the end of the 20th century. Linton (2010) critically analyses Gleick's *Water In Crisis: A Guide to the World's Fresh Resources* (1993), and concludes that the constitution of a water crisis[i] is inevitable whenever the quantification of water as an abstract is brought into relation with the quantification of abstract people. By the year 2000 Gleick began to refrain from using the term 'crisis', and admitted that all the projections and estimations of future freshwater demands made over the past 50 years had invariably turned out to be wrong, because in changing historical circumstances people find new ways of relating with water, discover new forms of resourcefulness, and apply new techniques to mediate their relations with water (2000). The powerful alarmist discourse of a global water crisis, it can be said, is created and maintained by the mixing of abstract notions of water, with people in their abstract statistical guise as 'population'. This discourse is supported by the outputs of global hydrological models run by scientists, some of whom believe their work to be politically-neutral. Population growth and dynamics remain as the most oft-stated and popular 'driver' to the global water crisis. The UNESCO's International Hydrological Programme (UNESCO-IHP) quotation, cited below, makes clear this assumption:

*"Population density and per capita resource use have increased dramatically over the past century, and watersheds, aquifers and the associated ecosystems have undergone significant modifications that affect the vitality, quality and availability of the resource. Current United Nations predictions estimate that the world population will reach 9 billion people in 2050. **This exponential growth in population – a major driver of energy consumption and anthropogenic climate change – is also the key driver behind hydrologic change and its impacts**"* (UNESCO-IHP, 2011: 1) [Emphasis added in bold].

Global institutions repeatedly point their finger at poorer countries, their 'weak' governments, and the pressures their economically poor populations place on natural resources. This conveniently diverts attention from the effects of the global capitalist/neoliberal political economy and the pressures it creates on governments, people and the environment in its production of the affluence that those in power (and living in affluence) have come to consider normal. The UN's World Water Assessment Programme (UN-WWAP) quotation, below, informs us that it is 'our' collective pursuit of higher living standards that drives water crises. Here, all humans are conveniently lumped together as one homogenous 'community' grouping:

"The amount of freshwater on Earth is finite, but its distribution has varied considerably, driven mainly by natural cycles… That situation has changed, however. Alongside natural causes are new and continuing human activities that have become primary 'drivers' of the pressures affecting our planet's water systems. These pressures are

*most often related to human development and economic growth… **Our require-ments for water to meet our fundamental needs and our collective pursuit of higher living standards**… Important decisions affecting water management are… driven by external, largely unpredictable drivers – demography, climate change, the global economy, changing societal values and norms, technological innovation, laws and customs, and financial markets."* (UN-WWAP, 2009: xix) [Emphasis added in bold].

Nowhere is 'affluence' listed or mentioned as a driver of water scarcity, nor is inequality in distribution of wealth problematized. These omissions are not made mistakenly. The creation of a water crisis, and the focussing of attention on poorer countries with 'weak' governments, provides the groundwork for the promotion of market-based solutions to water problems, with profits to be made by powerfully-placed actors including governmental, intergovernmental, and corporate actors.[ii] This is achieved by framing problems and solutions in technical and hydrological terms. Such a discourse obscures the alternative (unheard) views of local-level diverse water users and civil society groups (located in diverse geographical, political and social contexts), for rights-based initiatives, or devolution of management and control over natural resources to local water users. On water's problematic social geography Mustafa writes:

"… to switch focus from the political economic factors that affect access to resources is, in fact, tantamount to turning a blind eye to the injustices at the heart of producing affluence for the few at the expense of scarcity and misery for the many… The sterile per capita freshwater availability numbers may seem alarming… but they really serve to divert attention from water's problematic social geography, from its extremely skewed distribution across sectors and across social groups, and from discursive construction by the power elites as a "resource" to be deployed in isolation from its ecological and social roles toward modernist economic development." (Mustafa, 2007: 486-488).

The World Water Council's World Water Vision: Orwellian *Newspeak*

In 1996 a motley group comprising the World Bank, United Nations Development Programme, water services industry representatives and water 'experts' convened the World Water Council, and in 2000 the *World Water Vision,* and its companion document *World Water Security: A Framework for Action,* were presented at the World Water Forum. These documents, drawing heavily on the fourth Dublin Principle, framed water as a scarce resource and an economic good that must be managed in an economical and integrated way (Linton, 2010). The fourth principle states that 'water has an economic value in all its competing uses and should be recognised as an economic good'. This contradicts the previous three, which state that 'fresh water is …essential to sustaining life, development, and the environment', that 'water development and management should be based on a participatory approach…' and that 'women play a central part in the provision, management and safe-guarding of water'.

The idea of water as an 'economic good' is troubling, because it is a reductionist way to view a multifaceted resource; it ignores localised visions concerning water and water resources management, and market forces do not operate in a vacuum, rather they build on existing social and power relations (Mehta, 2000). For example, irrigation studies conclude that water pricing alone is not the solution to improving water usage efficiency, rather it may be a problem (e.g. Hellegers et al. (2007a) for India, and Hellegers et al. (2007b) for Morocco). Mehta points out that the World Water Council (secretariat in Marseille) and the World Commission on Water (secretariat at UNESCO in Paris) have close partnerships with French-based utilities and water companies such as Vivendi, which could be interpreted as the active promotion of powerful corporations in current water debates. The World Bank and such corporations have argued that the state has hitherto been unable to provide basic infrastructure, so market based solutions may be the answer. Mehta concludes that narratives of water 'crises', water wars, and water shortages obscure issues concerning unequal access to and control over water, that there needs to be greater pluralism in polarised discourses and debates over water as a 'human right', 'as commons' and 'as an economic good'. Rather than drawing on vague political, economic or theoretical assumptions which lead to normative, rhetorical, speculative and apolitical discourses, empirically grounded facts and realities ought to be established by critical research at macro, meso and micro levels (Mehta, 2000).

According to the Indian scholar Vaidyanathan (2006), an alternative agenda is being advocated by "a section of opinion in major international lending institutions and some international research organizations… known for their capacity to influence thinking of third world governments and policy makers". This agenda seeks the "[p]rivatisation of water resource development and management on the basis of well-defined property rights in water guaranteed by law, leaving prices and allocations to be decided by the market" (ibid.: 180). Academic research however, such as the edited volume on irrigation pricing by Molle and Berkoff (2007), challenges this rationale. Water's nature, as a common pool resource, necessitates that its costs and benefits be shared by water users. To Vaidyanathan this requires a socio-political, not a market-based process.

Decentralisation and increased water-user participation, combined with the reduced scope and nature of government's direct involvement in water management could leave a greater role for water-users, NGOs and civil society to address the tasks (2006: 181). However this will not be easy. Assessments of Irrigation Management Transfer (IMT) and Participatory Irrigation Management (PIM) programmes suggest that success in irrigation reform can be elusive (Mollinga and Bolding, 2004, Mukherji et al., 2009).

Driving the message home: The poor are to blame

'Driver' is the key term used by international organisations to explain the natural and social processes affecting our planet's water systems. The latest report of the UN's World Water Assessment Programme, *Water in a Changing World* (UN-WWAP, 2009), groups the main drivers that exert pressure on water resources in the following categories: demographic, economic, and social. Population dynamics such as growth, age distribution, migration and urbanisation create pressures on freshwater resources through increased water demands and pollution, and the need for more water-related services. Growing international trade in goods and services aggravates water stress in some countries while relieving it in others (virtual water). Changes in lifestyle reflect human needs, desires and attitudes, and are influenced by culture and education, by economic drivers and technological innovation.

For example, the section headed 'poverty' states that poor people degrade their environment to survive whatever the consequence, in the process creating scarcity and pollution (p37). The next section is headed 'education', which states that an educated populace has a better understanding of the need for sustainable use of water (ibid.). The report explicitly states that lifestyles and consumption patterns are the sum of all drivers, and that the production of goods to satisfy growing wants is often not possible without the overuse of natural resources. While a point is made that the Chinese are eating more meat, there is no mention that Americans and Europeans eat unhealthily excessive and unnecessary amounts of meat.

The section on drivers concludes by saying that 'raising awareness to bring about behavioural change is one approach, but still an elusive goal' (p39). One is left to wonder if the UN-WWAP report is subtly attributing water problems to the less-wealthy segments of societies residing in poorer countries. What is strikingly absent from the UN-WWAP report is any mention of over-consumption by affluent segments of societies worldwide.

The behaviour of richer and well-educated countries and their people, of wealthier segments of societies worldwide, and of multi-national companies that actively destroy environments/ ecosystems in their pursuit of material goods and profit, are not mentioned, let alone castigated. The authors are themselves likely excessive consumers of goods and energy, and recipients of huge pay cheques, and hence unwilling or unable to speak out – if it evens crosses their mind to do so in the first place.

The recent UNESCO report, *The Impact of Global Change on Water Resources: The Response of UNESCO's International Hydrological Programme* (UNESCO-IHP, 2011), takes a similar stance to the above UN-WWAP report, though is slightly more alarmist, presumably in an attempt to justify its work. The report lists several drivers, though tends to favour the highlighting of population dynamics. The drivers of global change are stated to be: population growth, climate change, urbanisation, expansion of infrastructure, migration, and land conversion and pollution. Aside from climate change in its anthropogenic form, the remaining drivers are processes that have been on-going for centuries; however this is not made explicit.

Nowhere does the UNESCO-IHP report mention the global political economic system that causes these drivers to have negative affects upon the environment (and people). For example, deforestation, mining or the oil industry, much of which provide cheap timber, metals and fuel to benefit wealthier countries and segments of societies, while creating regional and local instabilities across the globe and in the process destroying local hydrological regimes, get no mention. The report is saturated with images of 'poor' people and degraded environments, but not images of expensive private cars, gadgets and goods in wealthy countries, or luxury tourist hotels in tropical locations (etc.), all of which consume vast quantities of fresh-water, often in geographical locations where water is scarce and local populations' impoverished. A well-known example is that of Coca Cola company, which established bottling plants in India's Kerala and Rajasthan states, and drained aquifers causing drinking and agricultural water shortages in surrounding villages. Locals were forced to undertake major campaigns and go to court to shut down the company's operations. In Columbia, Coca-Cola is accused of using mercenaries to kill trade unionists (*www.bilaterals.org/?in-colombia-free-trade-brings more,* accessed on 21 May 2014)

The UNESCO-IHP report points out that data are sparse in the 'developing world', and rarely shared across ministries or institutions. Yet is this not understandable in a political economic world order dominated by a few powerful countries and corporations, and where states and their people theoretically have the right to self-determination and independence from hegemonic international organisations?

Overall the report presents an alarmist view of freshwater crisis, and from the image thus created states that "since these changes are a global problem, a response to its impacts must also be international" (UNESCO-IHP, 2011).

Concluding comment

The 'global water crisis' is a discourse created by powerful actors that serves to divert attention from the global, regional and localised political and social circumstances that produce freshwater problems. Solutions are framed in predominantly technical and hydrological terms, which serve to veil certain assumptions, i.e. that economic growth for modern development is the pathway ahead for all humankind, to be achieved through privatisation of all resources (and destruction of remnants of collective structures which impede progress). Many people actually believe such assumptions (a "The Economist" worldview) also indicated by a reluctance to shed the use of the term "developed countries" (economies are formalised, and infra-structure in place, but how developed are the people?). The discourse arguably serves to justify market-based solutions at the expense of alternative views such as right-based and community-led initiatives.[iii]

Therefore healthy scepticism is required when reading international and inter-governmental agencies' documents (especially when one considers that many of their scientists claim to have no agenda – to be objective – a claim that can hardly be sustained given the scale and gravity of the social and environmental challenges faced by humankind).

This paper concludes with a call for more contextualised regional and local studies of freshwater scarcity and the problems surrounding the distribution of resources. Modelling of freshwater availability and scarcity at continental and global scales, even national scales for larger countries, serves little purpose other than to fuel alarmist calls. Huge financial sums are being allocated from governments (and their tax-payers) to global bodies work that ends up being presented in glossy reports and at conferences, however it is difficult to see how the poor and dispossessed, or ecological systems, benefit from this.

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[i] What Linton calls 'modern water'. Until recently, "water has most commonly been thought of as a resource that could be considered and managed in abstraction from the wider environmental, social and cultural context(s) in which it occurred" (Linton, 2010: 6).

[ii] To Pierre Bourdieu, neoliberalism proceeds by destroying collective structures which may impede pure market logic. Many water experts hold the view that water management necessitates collective action. Many humans consider collective structures as normal, even natural, and are uncomfortable with the increasing reduction of all human/social interactions to economic, mercantile transactions.

[iii] Bakker (2005, 2007), analyses the commodification of nature, and recommends greater conceptual precision in our analyses of neoliberalisation. Neoliberalism is not monolithic, and it creates political opportunities that may be progressive (2007).

Reports & Analyses

The Political Ecology of Salmon Aquaculture in Chile

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Introduction

Statistically seen, of the 15.2kg fish every German consumes per year, 15% is salmon, which is the third most popular fish in Germany after Alaska-Seelachs and Hering (Keller/Kress 2013: 9). But where does the salmon that ends up on our plates every 6th time we eat fish come from? There's no obligation for producers to declare the origin of their fish products, but if they do so, the latin name of the fish, catching method and catch area should be declared. Salmon, of which about 40% are captured in the wild and the rest brought up in aquacultures, could then be declared as follows: Salmon (salmo salar), aquaculture from Chile. Without any doubt, this makes consumption more transparent, but the standards of production – both, social and ecological ones –and the ecological impacts are still kept in the dark. Looking at agricultural farming as it takes place in Chile's 9th and 10th region is even possible from the home office: Fishing nets and cages can be seen from above with the help of online map services. Still invisible are, of course, ecological and social impacts of this way of food production. Indeed, salmon aquacultures are responsible for severe damages to the local fjord ecosystem. Food residues and faeces drop down from the cages, fish are fed with antibiotics and mass escapes due to holes in the cages are a serious challenge for the fjord environment that has never been a home for salmon until humans brought it there. But problems continue on land: a high risk potential for divers and low wages in general are the price for an employment in the structurally weak area.

This report deals with the consequences of aquaculture in Southern Chile being viewed in the context of political ecology. Originally being developed by geographers, the projection of political ecology (PE) unites analysis of natural as well as social sciences. It is based on the assumption that recent environmental problems cannot be analysed from one side only, as reasons and solutions for problems are usually multidimensional.

Regarding salmon aquaculture in Patagonia/Chile, I have two theses:

a) There is an imbalance of power between the salmon industries, local population and environmental associations towards the local population which is expressed in the conflict of salmon aquacultures in Southern Chile.

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b) Earnings of the salmon aquacultural business are internationalized while the negative environmental impacts remain on a local level.

First, I will give an overview of the field of PE and then the problem analyzed in this paper will be described clearly. Afterwards, I'll give a description of the environmental changes due to salmon farming in Chile and the actors involved (salmon industry, local population and environmental associations). The last part contains a discussion of the theses and short future prospects of possible developments in the field.

Literature

A short, detailed overview of the wide field of PE is delivered by Krings (2008), while a more detailed and methodologically more precise is given by Robbins (2004). Bryant (2001) clusters different mentors of PE which helps to understand better the evolution of the field. Concerning salmon aquacultures, scientifically proved material comes from environmental organisations. Doren/Gabella (2001) wrote a very detailed and elaborate report on the issue for Fundación Terram which treats both the ecological and social costs of the problem. Same goes for García Moreno (2005), who worked for Veterinarios Sin Fronteras (VSF). A newer research paper from Ecoceanos is written by Igor Melillanca/Díaz Medina (2007). Fortt Z./Buschmann (2007) published a report focusing on the (mis)use of antibiotics. More important facts and numbers about aquacultural salmon farming in Chile come from an interview done by Morgenthaler (2011) with the German filmmaker Wilfried Huisman. Regular statistics about fish consumption in general are compiled by the Food and Agriculture Organization (FAO), especially in their statistic year book by Gennari/Keita/Schmidhuber (2013: 123-199).

Political Ecology

PE is not a self-contained theory, but a theoretical-conceptional frame, in which various approaches can be summed up. They all have in common that they "denaturalize certain social and environmental conditions, showing them to be the contingent outcomes of power, and not inevitable". (Robbins 2004: 13) Bryant (2001) distinguishes neo-Marxist, post-Marxist, feminist and post-structuralist schools within PE. All of them focus on analysing social environmental conditions which means that environmental issues are seen as (re)allocation issues between different social actors such as minority groups, corporations and politicians. Due to the variety of the approaches there is no consistent methodological framework. PE constantly tries to do two things at once: critically explaining what is wrong with dominant accounts of environmental change, while at the same time exploring alternatives, adaptations, and reactive human action in the face of mismanagement and exploitation." (Robbings 2004: 12)

Piers Blaikie and Harold Brookfield, the two geographers who founded PE in the 1980s, understand their field of research as a "geography-based research field that nonetheless maintains strong links to anthropology and sociology." (Blaikie/Brookfield 1987:: 17) Links to political science are given by the fact that the social construction of natural spaces is an expression of potentials of power and spheres of influence, which is a genuine field of study for political scientists. Blaikie and Brookfield published empirical studies and worked mainly on Development Studies, which is also a topic that involves various disciplines, therefore PE has a high potential for interdisciplinary work. The reason for the increasing significance of PE obtained in the 1990s lay in the fact that it – in contrast to former approaches – put environmental problems in the context of unequal power distributions and economic constraints In Germany, social ecology has become popular. Social ecology has a lot of intersections with PE, but was founded explicitly with reference to critical theory (see also Becker/Jahn 2006).

Salmon aquacultures in Chile – the environmental conflict

Atlantic salmon (Salmo salar), was originally not at home at the Chilean costs and is therefore an invasive species. It was brought to the country only about 100 years go in order to make financial profit out of it and cover the demand for protein in the local population. (Doren/Gabella 2001: 7) In the 1990s, after the end of the military dictatorship under General Pinochet, salmon breeds experienced an enormous boom in Chile and the country is now the second biggest producer of salmon behind Norway. About two thirds of salmon aquacultures worldwide are located in Norway and Chile. (FAO 2009: 75) Within Chile the centre of salmon farming is based in the 10th region around Reloncaví. (Doren/Gabella 2001: 7) Most of salmon cages are located there a down south in structurally weak areas with a low population density, but partly untouched fjord landscapes. Today, in Chile 98% of the farmed salmon are for export. (García Moreno 2005: 8)

The conflict arising from this practice is the endangering of the fjord ecosystems by various factors which has consequences for local fishermen depending on good environmental conditions. Furthermore, social conflict can be found between people depending on jobs in the salmon industry, but in the same time being exploited in their job. The problem gets even bigger if future perspectives are involved: a growing income sector can be the (eco-) tourism branch, which depends on the attractiveness and ecological intactness of the region, which will be progressively destroyed if salmon industry continues to work the way they do at the moment.

The massive amounts of production and the exposure of the fjords to the invasive animal have of course an influence on the landscape and the local ecosystem. To measure the degradation of landscapes due to human interference, Robbins (2004: 91-96) suggests four indicators: loss of natural productivity, loss of biodiversity, loss of usefulness and creation or rise of environmental risks. In the following, I will give a detailed description of the negative impacts of salmon farming on the environment.

Atlantic salmon – not a domestic species in Chile

Salmon in agricultures is kept and raised in under-water cages, which should prevent the animals from escaping, but doesn't isolate them from their environment. Big amounts of faeces (containing phosphor and nitrogen), feed residuals (containing medicine, especially antibiotics) and residues of dead fish fall down on the sea floor underneath the salmon cages. (García Moreno 2005: 27) Sediments that stay there change bacterial flora on the ground and, as a consequence, have an influence on the food chain. (Fortt Z./Buschmann 2007: 9) As mentioned above, salmon is an invasive species, therefore its implementation into Patagonian ecosystems means an enormous risk for the latter. What makes it particularly even more risky is the problem that sea lions on their search for food damage the salmon cages, so that salmons escape, spread and spawn. Given the fact that there are no other massively polluting industries where salmon aquacultures are located, the consequences of this intervention in the natural space are clearly visible.

The risk of escaping salmons

It happens regularly that sea lions looking for food or thunderstorms cause grave damages to the salmon cages so that fish can get outside and spawn freely in the fjords. Escapes are "one of the most serious environmental problems resulting from open-water aquaculture operations"(Oceana 2012), because salmons have a high demand of food and therefore threaten or even erase other species. In Chile, the number of escaped salmon out of aquacultures is up to 1 million.[i] The social component of the problem is that it is forbidden and punishable to capture or angle the escaped fish, because they are officially private property of the salmon corporations. Fishermen, whose basis for work and nutrition is already endangered by the industrial competition, find themselves in the middle of a dilemma.

Epidemics and antibiotics

Because salmon are kept with only little space in the cages, there is a potentially higher risk that the whole stock falls ill. One of the most serious illnesses is the ISA virus (Infectious Salmon Anaemia). In 2012, scientists of the University of Bergen could prove that the virus was introduced to Chile from Norway. As there are already existed experiences with the dangers of contagion in Norway earlier, it can be said that the handling of a possible outbreak in Chile was negligent. The biggest ISA epidemics in Chile happened in 2007 and 2009 (FAO 2009: 75), in 2013 ISA spread again. (Trovall 2013)

In order to lower the risk of illness and epidemics, the feed of the salmon already contains antibiotics. Chilenean law allows a much higher amount of antibiotics in foodstuff than in Norway. (Fortt/Buschmann 2007: 6). Residuals of the antibiotics can also get into the human body via the food chain and so cause possible resistances towards antibiotics.

Moreover, wild fish are also affected because they eat foodstuff remains that aren't eaten by the salmon and then fall out of the cages. (Fortt/Buschmann 2007: p.6).

Follow-up problem: exploitation of other fish species for feeding the salmon

When they grow up (and grow fat), salmon needs more animal proteins than they deliver when they grown-up. The data on the exact amounts varies: Marine Harvest, worldwide leader in the market for salmon aquacultures, states on their homepage that the amount is 3kg wildly fished fish and some biologists say it can be up to 8kg (Morgenthaler 2011). How much the amount of fish that is fed to other fish is, becomes clearer when looking at the numbers of the FAO: out of 148 tonnes of recovered fish, 128 tonnes are directly for human consumption. (FAO Statistic Year Book 2013, Part 3: 146) Independently from the exact amount of fish meal that is fed to salmon in the breeding locations to make them grow, it becomes clear that a sustainable salmon production is not possible, because it is based on the exploitation of other fish species.

Another ecological follow-up problem of the massive salmon farming is the endangering of the protected species of the sea lion (Otaria flavescens). Sea lions are often killed, because they damage the salmon cages looking for the fresh food inside. (Igor Melillanca/Díaz Medina: 34)

The social dimension: bad working conditions and dependencies in the salmon industry

Beyond the ecological point of view, the environmental conflict around salmon aquacultures also shows a social dimension that is not to be neglected, especially not while doing PE. The region of Los Lagos with the highest density of salmon aquacultures is among the poorest regions in Chile and has the lowest educational level. (García Moreno 2005: 15ff) Agriculture, including fishing industry, is still the most important economic sector, even though tourism is becoming more and more important. The surrounding nature attracts tourists looking for adventure sports as well as hobby anglers. In 2004, about 45,000 people in Los Lagos region were directly or indirectly employed in the salmon industry (SalmonChile 2013), but not even 7000 – that means less than 10% - were organized in labour unions. (Igor Melillanca/Díaz Medina 2007: 7-21) Especially for the divers working at the salmon cages, their job bears a high risk of accidents. Diving lower than officially permitted, pressure to go diving during bad weather conditions, bad equipment and an insufficient training and control make their job one of the most dangerous. In Chile, on average every month a diver working in the salmon industry dies, while in Europe this happens every three years (Igor Melillanca/Díaz Medina 2007: 14).

Regarding the landscape degradation indicators by Robbins (2004), what can be said about the human impacts on Patagonian landscape?

Loss of natural productivity: Due to regularly happening salmon escapes out of their damaged cages, the coastal ecosystem suffers, because salmon's enormous hunger diminishes the domestic fish stocks.

Loss of biodiversity: To provide feed for aquacultures, fish is recovered along the whole Chilean coast, which is leading to a major overfishing problem, which industrial salmon farming is also responsible for. Furthermore, escaped salmon threaten and endanger the local ecosystem while looking for the massive amounts of food they need. Unfortunately, exact data on how the ecosystems change under influence of escaped salmons has not (yet) been provided, but what is already obvious is the perilous situation of sea lions who are already protected, but still killed because they can do harm to the salmon cages.

Loss of usefulness: At least two branches of economy depend on the intact Patagonian fjord landscape, local (artisan) fishery and tourism. Fishermen are highly affected by the salmon industry, because of escaped salmon diminishing the populations of the domestic fish species. On top, they can get juridical problems if they fish a salmon which is property of a company, even when swimming around freely. How much tourism is harmed actually can't be stated in this paper, but there's the potential danger that the regions affected by salmon industry loose attractiveness, especially for angler tourists looking for domestic species.

Creation or rise of environmental risks: In my opinion, so far there is no definitive correlation between salmon breeding and new/rising risks that can be proved, but some are probable regarding the endangered status of sea lions as a key species in the local ecosystem or some effects connected to the massive use of antibiotics.

Actors in the conflict: Salmon industry

Salmon is one of the most important export products of Chile and more than half of the total amount of exported fish products is salmon (SalmonChile 2013), even 98% of all salmon farmed in Chile is intended for export, especially going to Japan and the United States (García Moreno 2005: 9). In 2005, three of the biggest salmon exporters were transnational corporations; still the market leader is Marine Harvest (ibid). Marine Harvest, the global market leader for salmon aquacultures and based in Norway, has been heavily criticized for their destructive way to farm salmon as well as the dangerous working conditions. (See also the movie "Lachsfieber"by Wilfried Huismann) Since 1986, all salmon producing companies are united in the association SalmonChile, which has 54 members at the moment and its goal is to represent the common interests of salmon industry to the state and investors. Given only the large number and importance of its members, SalmonChile is a largely influential actor, which enables salmon industry to speak with a common voice.

In Chile, environmental standards are lower than for example in Norway and growing rates in the salmon branch account more than 10%, which makes the country a paradise for investors and internationally operating companies. (Morgenthaler 2011) Good preconditions are not only to be found in Chile's natural resources, but also in the economic conditions: Since the 1980s the country follows a highly neoliberal course, strictly sticking to the principle „grow first, then regulate" (García Moreno 2005: 6) and also within the society, major concerns about environmental issues are hard to find. Despite the very low regulative environmental framework, SalmonChile point out that in Chile no other sector would have to bear that much regulation regarding the environment like the salmon industry.[ii] Not only being committed to "big business interests", the association stresses the local commitment of its members, e.g. donations to school, libraries and other public places in the salmon producing regions. All in all, the capital that is generated in Chile by salmon breeding only partly stays there. Big amounts of money leave the country and the political and economic framework favours this situation (Igor Melillanca/Díaz Medina 2007: 5), which attracts even more investors.

Local population and employees in the salmon industry

Obviously it is not possible to summarize the whole population of aquaculture-hosting regions as a collective actor with homogeneous norms and ideas, but those employed in the salmon industry bear more or less similar working conditions. As already described above, working conditions in the salmon sector are precarious in the sense that there are no labour unions, there's a certain dependence on the few jobs offered and there were even court cases against some employers. (Igor Melillanca/Díaz Medina 2007: 7-21) There are scattered acts of protests and strikes, but so far they are not connected or collective to an extent that allows the creation of a strong and contained actor – even though there would be a basis for common demands such as secure contracts, better employment protection, proper safety measures and the right to organize in labour unions. Ecoceanos states: “50% of the members of labour unions belong to superior organisations, which means they are connected through federations, which shows an actor that is fragmented, shattered and has no capacity to negotiate.“ (Igor Melillanca/Díaz Medina 2007: 16). The same senti- ment goes for tourism. There is no association of interest that could criticize the practices of the salmon industry. Although, the loss of biodiversity and destruction of coastal ecosystem will have an impact on the development of tourism, because they promote the untouched and intact natural landscape which is strongly connected to Patagonia as you might know it.[iii]

Environmental organizations

Eco-social problems around salmon aquacultures in Southern Chile belong to the very core issues of the country's relatively young environmental movement. One of the organizations running a campaign on salmon farming is Ecoceanos, founded in 1998. They advocate for the protection and the sustainable treatment of marine/coastal ecosystems and resources, but also want to strengthen civil society and promote the active participation of small organizations in the political process. In order to achieve these goals, their methods are environmental education, capacity building, research and trying to encourage broader public discussion through publicity. Ecoceanos is also part of Red Puentes Chile, a nation- wide association of eleven organizations working on social and ecological issues and who have committed themselves to sustainable development. Red Puentes itself is an international NGO containing seven national branches.

Another NGO dealing with ocean issues in Chile is Oceana, the biggest international organization working only on the protection of oceans and their ecosystems, founded in 2001. In addition to offices in the USA, Europe and Central America, they also have an office in Santiago de Chile. Their campaign on salmon aquacultures is only one of many, but showed a visible success when Chilean Congress tightened the regulations on the prevention of salmon escapes and restriction of antibiotics in feeding. in 2010 (Oceana 2013). Fundación Terram, a Chilean environmental NGO founded in 1991, mainly focusses on research and provides studies and articles delivering concrete advice on how to achieve sustainable development. Additionally, they want to support social engagement and cooperate with different social and ecological NGOs.

Last but not least, there is the association Veterinarios Sin Fronteras (Vets Without Borders) who struggle for worldwide food justice and against the reasons for hunger in the world. They aim to change the economic system in a fair and equal way. They have no office in Chile, but substantial material on a scientific basis about salmon is provided by the Spanish section (see Cabrera 2003).

Conclusion

Without any doubt, the development and expansion of the salmon industry in Southern Chile have led to a considerable change, especially in respect to the degradation of the landscape. According to the criteria developed by Robbins (2004), we can clearly speak of a loss of natural productivity, biodiversity and usefulness in the centres of salmon production. Even though Robbins' fourth criteria, creation or increase of environmental risks could not be asserted, the other points clearly indicate a major intervention in the existing coastal ecosystem. The outcome is an environmental conflict that reflects different power potentials of the distinct conflicting parties.

First, according to the definition from the beginning, power can be seen as room to manoeuvre in the natural sphere. In the salmon industry, it is the salmon producing corporations who are the responsible for the destructive changes that take place in Patagonia, because they can maximize their profits treating nature like they do. In Chile, there is currently no mechanism that allocates (monetary) costs of environmental destruction to the originators, so, inevitably, these costs have to be borne those who suffer directly from the destruction itself. This proves the first point of my thesis.

Second, power can also be seen as room to manoeuvre in the political sphere that is guiding the policies. The analysis of the three actors presented above – salmon industry, local population and environmental associations – indicates the different state of organisation between them. While the industry has a powerful and professional representative of their interests in SalmonChile, their employees and the neighbourhood of affected regions are only marginally organized. That there's hardly any opposition against the practice of salmon industry, can be explained plausibly by the lack of jobs in the structurally weak area. People depend on jobs in order to earn their living at least on the short and medium term and it is the salmon industry that provides these jobs in Patagonia. Furthermore, it seems that the salmon industry even represses trade unions, which would stabilize the advance they already have concerning representation of own interests towards change agents. The third group I analysed, the environmental associations, is partly working internationally, but until now there have been neither collective campaigns nor demands to improve of aquacultural standards. This doesn't mean that their engagement is completely without consequences: the tightening in the regulation concerning salmon escapes in 2010 was achieved decisively under pressure from NGOs.

What is remarkable about the environmental associations is also that they don't only focus on the negative environmental consequences of salmon production, but also consider social factors. I interpret their social engagement as an expression of a broader understanding of sustainability, which can bring them sympathy within the population, but also connects, to a comprehensive criticism of the whole capitalist economic system. The higher degree of organisation the salmon industry has achieved, allows the corporations to assert they even vis-à-vis the state. Chile has implemented a strongly neoliberal policy since the 1980s which advantages trans- national corporations, but makes it even more difficult for those who want to implement regulative rule. So, in conclusion, even the second thesis is supported: earnings of the salmon business are internationalized, while negative environmental impacts remain on a local level.

Beyond the problem analysis, political ecology always seeks potential for change. Where can we find change towards a sustainable, ecologically friendly world in the example presented in this analysis? In my opinion, the developments in the Chilean environmental movement since the 1990s give good reasons for hope. The associations I have presented – Fundación Terram, Ecoceanos, Oceana and VSF – do great scientific work. Furthermore, they work strategically reasonably in international networks/an international context. It is important to integrate local initiatives, because the protection of the environment starts on a local level and the people only act when they see and understand the benefits they get from engagement for their environment. I see the environmental organisations as pioneers when it comes to social/societal change towards a (more) sustainable world. Especially in Patagonia also the (eco-) tourism branch has great potential to gain influence on political decision makers, because they are a growing industry, depending on an intact, natural environment and spectacular landscapes.

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Appendix

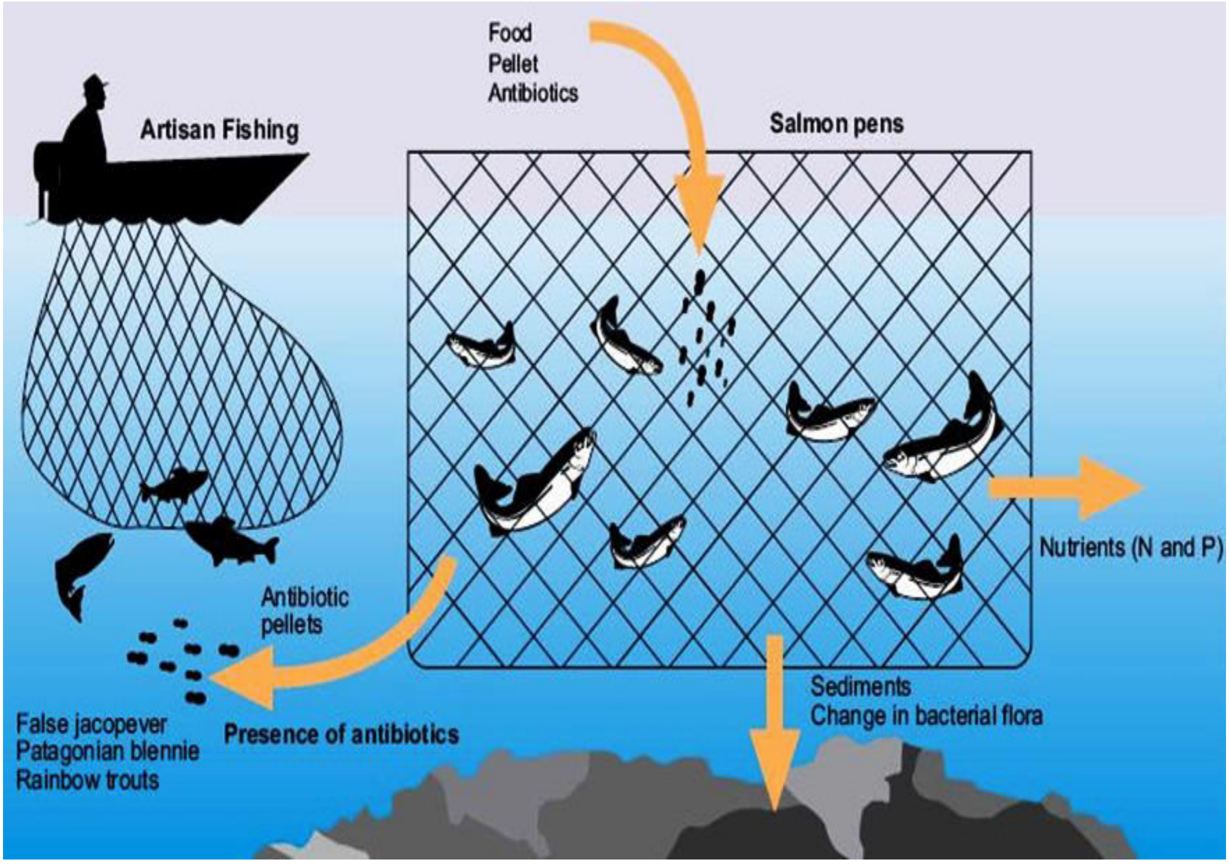

Figure 1 (Source: Fortt/Buschmann 2007:p.9)

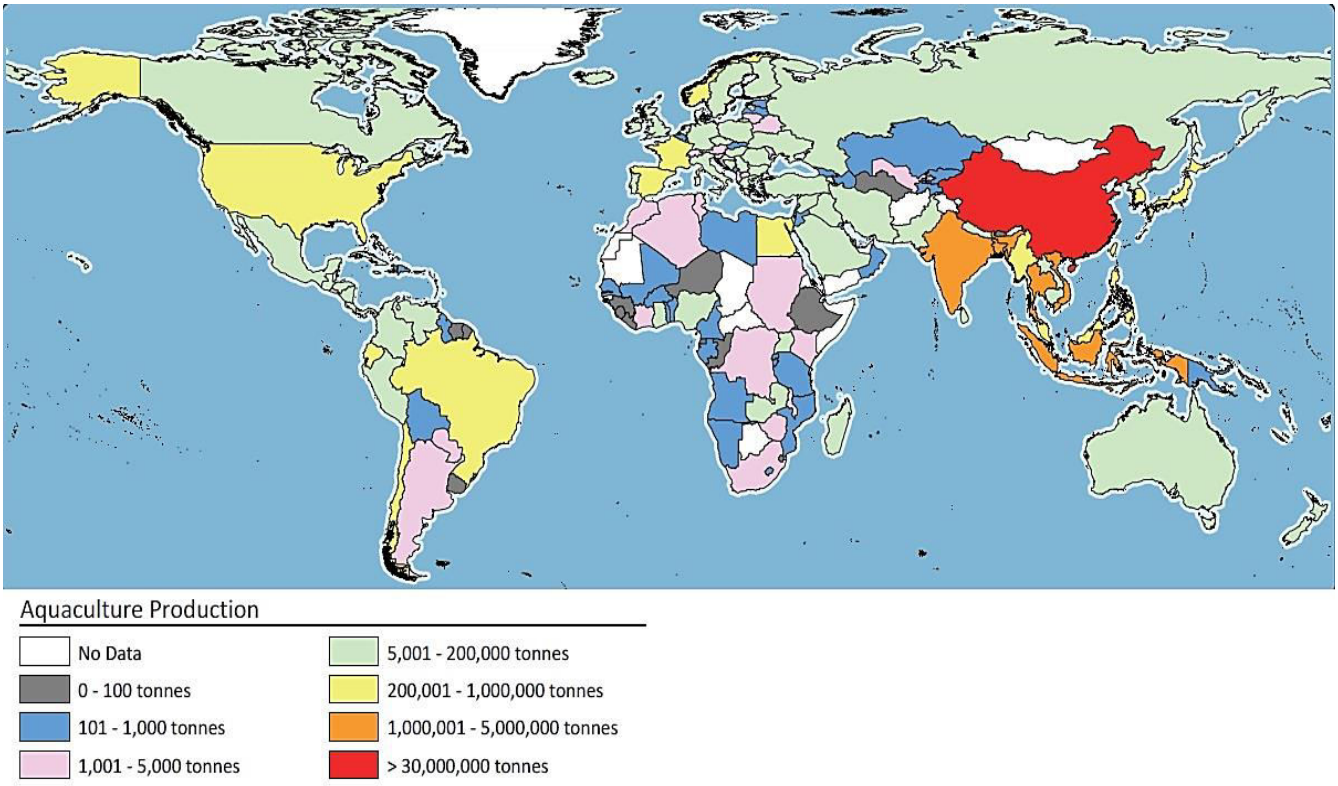

Figure 2 Aquaculture production of aquatic animals for human consumption (tonnes) in 2009

(Source: - NASO aquaculture maps collection , Food and Agriculture Organization of the United Nations (FAO), 2014 Accessed 10 June 2014 http://www.fao.org/fishery/naso-maps/naso-maps/en/)

Please find the fishery statistical time series at: http://www.fao.org/fishery/statistics/software/fishstat).

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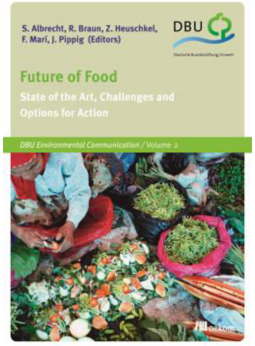
i A list of major salmon escapes in the 10. and 11. region between 2004 and 2005 can be found in Igor Melillanca/Díaz Medina 2007: 27-28.

ii Indeed a good overview of the different legal frameworks regulating salmon farming can be found on the homepage of *SalmonChile*: *www.salmonchile.cl//frontend/seccion.asp?contid=* 473&secid=6&secoldid=6&subsecid=141&pag=1, last accessed February 10, 2014

iii See *http://www.turismochile.com/guia/sur/*.



Future of Food: State of the Art, Challenges and Options for Action

A BOOK REVIEW BY BHUVANYA BALASUBRAMANIAM

Editors	S. Albrecht, R.Braun, Z.Heuschkel, F.Mari, J.Pippig
Title of book	Future of Food: State of the Art, Challenges and Options for Action
Year of publication	2013
ISBN	978-3-86581-419-7

Future of Food: State of the Art, Challenges and Options for Action is a compilation of very broad topics depicting sustainable global food production, its economic, social and environmental implications and the future ahead. The articles have been contributed by authors from all over the world and hence it is hard to assign an overall character to the book. At the same time, the sheer variety of the articles in the book gives the reader a good overall picture of not just the diversity of the topic but also the global situation. The authors and editors of this book are an interesting group of people with diverse backgrounds and professions ranging from researcher, journalist, historian, economist, anthropologist, etc. They have added to the true global depiction of the subject at hand, along with specific articles and case studies from regional levels such as Africa and South America as well as country level such as India, Sri Lanka, China and Brazil.

The book indeed gets the reader`s attention with its well-structured, clearly distinguished sections on "*Where Do We Stand?", "Challenges Ahead" and "What can we do?"* that helps in easy comprehension. The well-structured delivery of information further extends into the articles compiled in the book as well. Having said that, this book will do more justice as an appetiser in introducing someone to the complex world of global food production. This in turn raises a further question as to what extend can it get the reader involved since it clearly is not intended for hard-core subject specific researchers. Being an appetiser, it could have been more engaging with its presentation, especially with more visualization of the

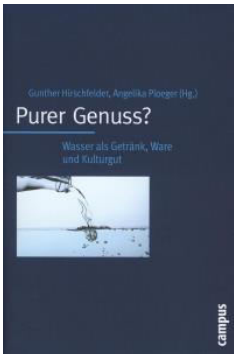
Balasubramaniam, Bhuvanya (2014). The Future of Food: State of the Art, Challenges and Options for Action. A book review. *Future of Food*: *Future of Food: Journal on Food, Agriculture and Society* 2(1): 175-176 ISSN-Internet: 2197-411X / OCLC-Nr.: 862804632

information.The only article with any visualization in the whole book is a case study from the Tarim river basin, China. Within the book certain articles discuss the political aspects of sustainable food production and get caught up with the bureaucracies of the political institutions, which does not help much in getting and retaining the attention of the reader. Unlike the past, today books also have the responsibility to reach out to the reader and induce maximum engagement, in addition to transmitting knowledge. Reader engagement and inspiration cannot be overemphasized in the realm of sustainable foodproduction where it struggles to expand its boundaries into the mainstream domain.

It is appreciable that the book covered almost every imaginable aspect of sustainable food production and situations have been elucidated at different levels as well, ranging from the broad insight at the sophisticated governmental/ institutional level to the raw reality of the subsistence farmers. But having covered the topic of fisheries, the book might as well have covered the topic of animal husbandry. Nevertheless, for a keen reader the book can serve as a great starter into the complicated world of sustainable food production.

Author information:

Bhuvanya Balasubramaniam is pursuing her master studies in International Food Business and Consumer Studies at the University of Kassel in Germany. She holds a bachelor in food technology, along with a work experience of 15 months at *Jayanti Group*, India.



Purer Genuss? Wasser als Getränk, Ware und Kulturgut

A BOOK REVIEW BY ANDREAS KLEINLEIN

Editors	Hirschfelder, G; Ploeger, A; Pudel, V; Schönberger, G;
Title of book	Purer Genuss? Wasser als Getränk, Ware und Kulturgut
Year of publication	2009
ISBN	978-3593390284

Water is getting more and more in the focus of the world. According to this there was a symposium of scientists of different subjects, organized by the "Internationaler Arbeitskreis für Kulturforschung des Essens" (International Study Group for Food Research) of the Dr. Rainer Wild-Stiftung in Heidelberg in 2006. This book developed from the presentations given at this congress, together with the ideas, that came in the discussions of the participants. In the book there are contributions which contain six pages and some contributions with more than 25 pages.

The authors are from many subjects, from the social sciences like folklorists, sociologists, historians, nutrition and food scientists and physicians. The variety of authors is topped off with a literary scholar and a physicist. Most of them come from a university Hereafter there will be presented the principal themes and also some of the particularly interesting aspects of the book:

The first main idea, which is discussed in many articles, is that mineral water is drunk more than tap water. This is strange, because the German tap water has a very high hygienic quality and also the minerals, which are in the mineral water, are incorporated in enough quantity through the nutrition. There are different explanations for this finding: First there is the question of image: Tap water is for example firmly connected with the thought of poorness and also with the fear of pollution. Whereas the mineral water has an image of a sporty and healthy drink.

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These images are created mostly through the advertisements of the mineral water industry. In addition to this, there is the phenomenon of artificial shortage of water through the price. Especially in gastronomy this leads to distinction. In general water is with the exception of exclusive bottled water a low-interest-product.

The second big theme in this book is the cultural view on the subject of water and drinking. There are contributions on the topic of water in the literature, water in the Jewish culture or the phenomenon of Lourdes water. Some articles are also about the history of water, drinking water and the drinking recommendations as well as the history of the distribution of water.

The third aspect of this book is the discussion, how much water should be drunk. In the book there are presented the recommendations, how much every person should be drink every day. Nonetheless the upshot of the most authors is: the people drink enough, if they drink when there are thirsty. This is fact is also valid for children. However there is the problem of old people, who can have less sensation for thirst.

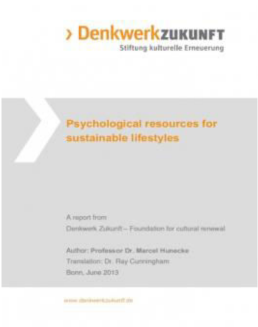
Lastly there is also the problem of the disposal of used water. Here one aspect is the question after a sustainably water system. From the point of view of the author the wastewater system of the 19th century is now outdated. He suggests a system that is based on the separation of the wastewater and vacuum technology. Another issue in the field of disposal is the discovery of active pharmaceutical substances. There may be dangers for the users of the water, but according to the author it is better to act now and not when it is too late. Also for this problem solutions are presented.

It also discusses water in language, the physical and chemical aspects of water, water in food production and more interesting facts about water and drinking. The book is focused on the situation in Germany. Further there are also links to other European cultures and also to the global issue of water.

Even if not every article interests everyone, the book is a good opportunity to see the topic area from different perspectives. Furthermore it provides a lot of background information and contributes to the discussion what and how much we are drinking and what and how much we should drink. The book is relevant as well as interesting for almost everyone, because it deals with the challenge of water, which concerns us all.
The interdisciplinary work on the field of water, like in this book should be continued and probably will gain in importance due to the fact that “Water is going to be the Achilles' heel of future viability of global development” like the editors formulate in their introduction

Author information:

Andreas Kleinlein is pursing his bachelor studies in Organic Agriculture at the University of Kassel.



Psychological resources for sustainable lifestyles

A BOOK REVIEW BY CRISTINA P. RODRIGUEZ TORRES

Author	Professor Dr. Marcel Hunecke
Title of report	Psychological resources for sustainable lifestyles
Year of publication	2013

There is an increasingly growing concern about climate change and environmental damage caused by unsustainable practices. This has led to the mobilisation of forces to look for alternatives as to how these problems can be offset.

Therefore a cultural transformation towards sustainable lifestyles is being promoted to raise consciousness. But this goes beyond reaching people and bringing a real change. It is not easy to shape human perceptions and alter attitudes and behaviours at the grassroots. It shall be required the support of psychological resources to assist people with this ecological living concept independently of material wealth.

A recent essay presented in 2013 by Denkwerk Zukunft, focuses on several important aspects to access and make use of these psychological resources. The author identified six psychological resources to increase the subjective wellbeing in terms of non material wealth. These refer to the capacity for pleasure, self-acceptance, self-efficacy, mindfulness, the construction of meaning, and solidarity. It is explained that these resources carry out different psychological functions and they can be balanced from each other. As a result, they can play a role on influencing positively the transition towards sustainability (Hunecke 2013, p.15ff).

The capacity for pleasure consists of the skills to positively correlate perceptions of sense stimuli or experiences with feelings of subjective wellbeing. These are obtained along life and are specific to each individual. Meanwhile, the self-acceptance resource combines the positive and negatives aspects that people judge and allocate to themselves. On the other hand, the self-efficacy or self -confidence resource includes the personal belief that one can achieve the projected objectives as a result of effort and perseverance (Hunecke 2013, p.18ff). These three psychological resources work as the main basis to develop a strong personality. Another principle is mindfulness, which represents the

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process and response to have a complete, conscious and non-judgmental attitude at the present moment. In contrast, the construction of meaning seeks for the appraisal and connection of a positive feeling such as security in individuals' life. The last psychological resource is solidarity. It involves a behaviour that seeks, from a collective point of view, the common good and the social responsibility (Hunecke 2013, p.27ff).

Finally, they were mentioned different strategies for the promotion of these psychological resources, which can lead to a non materialistic culture. For example, educational and health programmes, coaching, counseling or training can support the reinforcement of the mental and emotional approach in people. They can be performed at different individual and organisational levels such as, schools, public and private institutions and society (Hunecke 2013, p.38ff).

However there are some criticisms of the positive psychology and its extreme focus on individuals' feeling of happiness (Hunecke 2013, p.59). Therefore an important aspect to meet the sustainability goals is to think and act not only for the welfare and happiness of oneself but also for the community and ecology.

Author information:

Cristina is from Ecuador and obtained her bachelor degree in Nutrition Science in Argentina. At the present, she is pursuing her master studies in International Food Business and Consumer Studies at the University of Kassel in Germany. She has experiences in the field of clinic nutrition and food management, especially in catering services and hospitals in South America. Her aspiration for the moment is to complement her knowledge abroad in the food business sector, with focus on food technology, quality management and organic food system.

Alternative View

More than irrigation – The Balinese Subak system as a unique form of cooperative water resource management in Indonesia

Watch the full documentary here: *https://vimeo.com/98035926*

For over 1,000 years, the Balinese have developed a unique system of democratic and sustainable water irrigation. It has shaped the cultural landscapes of Bali and enables local communities to manage the ecology of terraced rice fields at the scale of whole watersheds.
The Subak system has made the Balinese the most productive rice growers in Indonesia and ensures a high level of food sovereignty for a dense population on the volcanic island. The Subak system provides a vibrant example of a diverse, ecologically sustainable, economically productive and democratic water management system that is also characterized by its non-reliance on fossil fuel derivatives or heavy machinery.

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In 2012, UNESCO has recognized five rice terraces and their water temples as World Heritage site and supports its conservation and protection. However, the fragile Subak system is threatened for its complexity and interconnectedness by new agricultural practices and increasing tourism on the island.

Length: 15:20 Min.

Produced by FLORIAN DOERR *in Bali, Indonesia (2014)*
Narrated by USMAN GHANI VIRK
Special Thanks to I Wayan Pineh (www.pinehbalitours.com), Rolf Rinkenberger, Nicolai Doerr

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Agroecology, small scale farming and regional development

The issue will be published in December 2014

More details will be available soon at the *www.fofj.org*